Sustainable Aviation Fuel Grand Challenge

October 2021 – September 2024 Progress Report

Prepared by the U.S. Department of Energy, U.S. Department of Transportation, and U.S. Department of Agriculture, in collaboration with the U.S. Environmental Protection Agency.

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List of Acronyms

ASCENT	Center of Excellence for Alternative Jet Fuels and Environment
BETO	Bioenergy Technologies Office
CAAFI	Commercial Aviation Alternative Fuels Initiative
CO_2	carbon dioxide
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FAST	Fueling Aviation's Sustainable Transition
FOA	funding opportunity announcement
FY	fiscal year
GHG	greenhouse gas
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Technologies
RD	renewable diesel
RDD&D	research, development, demonstration, and deployment
SAF	sustainable aviation fuel
USDA	U.S. Department of Agriculture

Preface

Since its announcement in September 2021, the Sustainable Aviation Fuel (SAF) Grand Challenge has had a significant impact in accelerating the acceptance and growth of SAF as a primary strategy in aviation decarbonization. Through a memorandum of understanding among the U.S. Department of Agriculture, U.S. Department of Energy, and U.S. Department of Transportation, a governmentwide effort including the U.S. Department of Defense, National Aeronautics and Space Administration, and the U.S. Environmental Protection Agency is helping to drive innovation that reduces cost, enhances sustainability, and expands production and use of SAF.

The Federal agencies supporting the SAF Grand Challenge accomplish this when they release new funding opportunities and initiatives aligned with the SAF Grand Challenge Roadmap, provide expertise and technical assistance to industry, increase interagency collaboration, and provide data, modeling, and analysis to decision makers.

From feedstock innovation and conversion technologies to building supply chains, policy, and valuation analysis, and enabling end use, the focus of the SAF Grand Challenge and the work of the agencies are making strides on the road to a decarbonized aviation sector.

The following report details some of the key accomplishments of the SAF Grand Challenge from October 2021 through September 2024.

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Sustainable Aviation Fuel Grand Challenge Interagency Working Group

Since the launch of the Sustainable Aviation Fuel (SAF) Grand Challenge, the SAF Interagency Working Group has accomplished the following:

- Published the SAF Grand Challenge Roadmap and SAF Grand Challenge Roadmap Implementation Framework.
- Coordinated agency information exchange and stakeholder engagement to understand industry developments. This included hosting seven SAF stakeholder events with agricultural producers, industry, and researchers, such as the "Deploying Purpose-Grown Energy Crops for Sustainable Aviation Fuel" workshop and two regional SAF financial workshops.
- Performed collaborative interagency research, development, demonstration, and deployment (RDD&D) aligned with the roadmap action areas as documented in this report.
- Developed the SAF Grand Challenge tracking metrics and dashboard. The dashboard metrics will be updated annually.

SAF Grand Challenge Tracking Metrics

The SAF Grand Challenge Roadmap outlines a whole-of-government approach with coordinated policies and specific activities that should be undertaken by Federal agencies to achieve 3 billion gallons per year of domestic SAF production that achieves a minimum of a 50% reduction in life cycle greenhouse gas (GHG) emissions compared to conventional fuel by 2030 and 35 billion gallons of annual SAF production to satisfy 100% of domestic demand by 2050.

To track progress on achieving these goals for the SAF Grand Challenge, the following four metrics have been developed:

1. **Estimated total U.S. SAF production.**

   Tracking annual U.S. SAF production is critical to assessing the progress toward meeting the near-term and long-term goals of the SAF Grand Challenge. The U.S. Department of Energy (DOE), U.S. Department of Transportation (DOT), and U.S. Department of Agriculture (USDA) will solicit SAF production volumes, either semiannually or annually, from producers. The data from different producers will be aggregated without attribution to any single U.S. SAF producer.

2. **Estimated life cycle carbon dioxide equivalent (CO_2e) reductions achieved with U.S. SAF production and use.**

   In addition to expanding domestic production of SAF, the SAF Grand Challenge also seeks to achieve a minimum of a 50% reduction in life cycle GHG emissions

for SAF compared to conventional fuel that it is replacing. Similar to the SAF production volumes, DOE, DOT, and USDA will solicit from producers the CO_2e emission reduction information associated with the production and use of the fuels they produce. These data will be aggregated without attribution to any single U.S. SAF producer.

3. **Planned production volumes of SAF in the United States.**

   As new SAF production facilities are announced, it will be important to understand the quantity of SAF these facilities will enable, as well as implications for meeting the near-term and long-term goals of the SAF Grand Challenge. A regularly updated database of public announcements, vetted for quality and used for planned production of SAF, will be created and maintained to track new facility production volumes and progress toward the SAF Grand Challenge goals.

4. **Applicable research, development, demonstration, and deployment (RDD&D) projects.**

   DOE, DOT, and USDA administer programs related to RDD&D of SAF-related projects. These efforts are critical to support the SAF enterprise and reduce the risk associated with technology, finance/investment, infrastructure, etc. Related to the various programs, the pipeline (technology readiness levels of 5–6 or higher) of RDD&D investment being put in place to enable the 2050 goal will be tracked. Specifically:

   a. Number of pilot and demonstration projects supported and the amount invested by U.S. Government agencies.

   b. Number of feedstock/integrated supply chains under development and the amount invested by U.S. Government agencies.

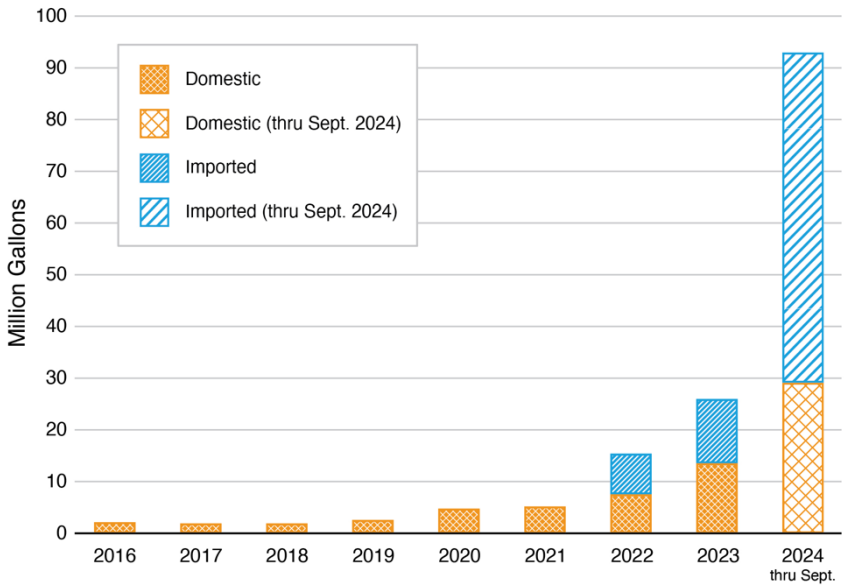
   c. Number of new American Society for Testing and Materials (ASTM) International annexes and the amount invested.

   d. Number of commercial deployments supported, and amount invested by U.S. Government agencies.

SAF Grand Challenge Metrics Dashboard

To track progress on achieving goals for the SAF Grand Challenge, four metrics have been developed: estimated total U.S. SAF production, estimated life cycle carbon dioxide reductions achieved with U.S. SAF production and use, planned production potential of SAF in the United States, and applicable RDD&D projects.

SAF Production

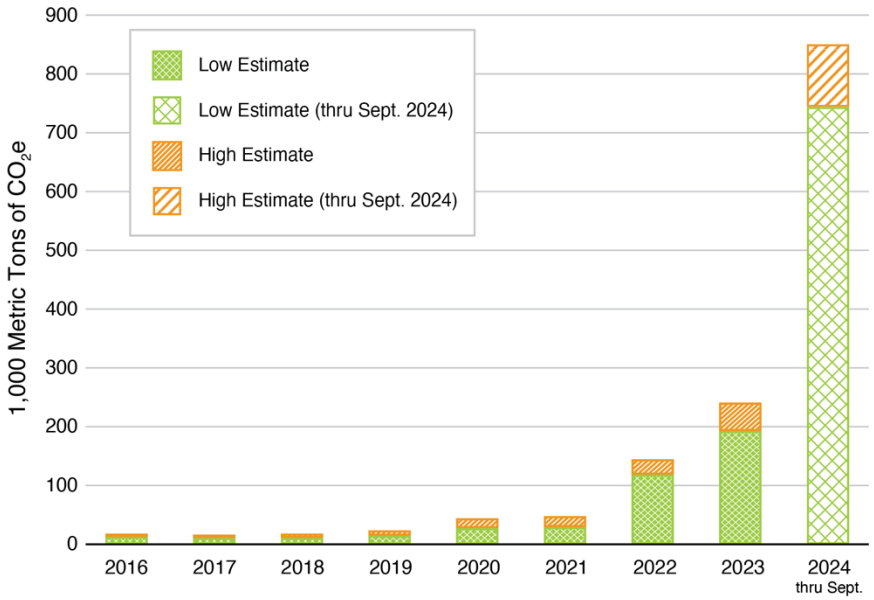


Source: EPA. 2024. "Public Data for the Renewable Fuel Standard." epa.gov/fuels-registration-reporting-and-compliance-help/public-data-renewable-fuel-standard.

- Based on U.S. Environmental Protection Agency (EPA) Renewable Identification Number (RIN) values, SAF annual domestic consumption grew from 5 million gallons in 2021 to 26 million gallons in 2023; 93 million gallons have been produced and imported through September 2024.[a]
- Through September 2024, SAF is predominantly based on conversion of fat, oil, and grease feedstocks through the hydro processed esters and fatty acids (HEFA) process.
- Based on public reporting, major commercial producers in this time frame include World Energy, Montana Renewables, Sinclair, and Neste Oil.

[a] *RIN data are currently the best available data source.*

Annual U.S. GHG Reduction



Source: Calculations based on historical RIN volumes and GREET[b] estimates of GHG emissions, and are for illustrative purposes only. Low estimate assumes domestic HEFA SAF is produced from soybean oil with a GHG reduction value of 55%. High estimate assumes domestic SAF is produced from used cooking oil (UCO) or tallow with a GHG reduction value of 80%. Both estimates assume imported HEFA SAF from UCO or tallow with a GHG reduction of 78%.[d]

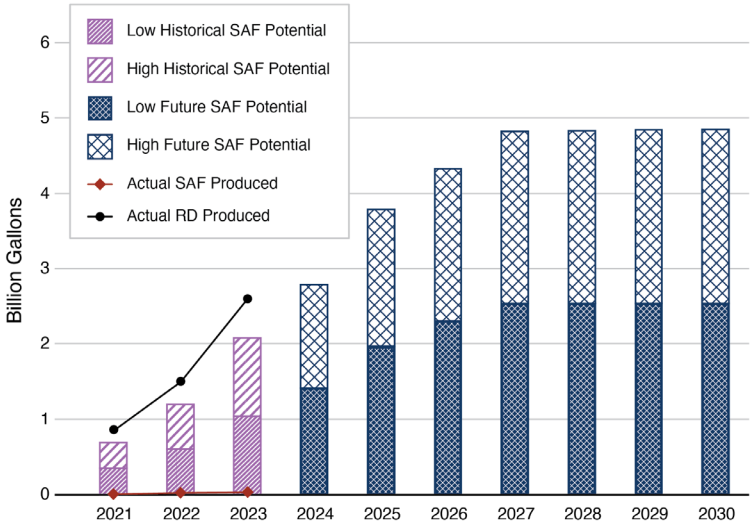
- Based on assumptions for the fat, oil, and grease feedstocks used to generate historical SAF RINs, life cycle GHG reductions range between 50% and 80% compared to conventional jet fuel.
- For 2023, this corresponded to a reduction in domestic GHG emissions of approximately 200,000 metric tons of CO_2e.[c]
- More than 750,000 metric tons of CO_2 equivalent domestic GHG emission reductions have been realized through September 2024.

[b] Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET®) life cycle models. https://www.energy.gov/eere/greet

[c] Estimates of GHG emission reductions are based on the RIN volume data in the previous figure and GREET emission values.

[d] GHG emission reductions calculated using the 40BSAF-GREET model with the sample base case input values for soybean HEFA and UCO/tallow HEFA SAF. For imported UCO/tallow HEFA SAF, a 2 g CO_2e/MJ penalty was calculated using the R&D GREET model based on ocean shipping from Singapore to Los Angeles.

U.S. SAF Production Potential



Source data for the future potential volumes will be available in a forthcoming ASCENT 01 publication. Brandt, K; Wolcott, M. (2024). RD data source: U.S. Energy Information Administration. SAF data source: EPA. "Public Data for the Renewable Fuel Standard."

- Based on a database of active projects,[1] between 2.6 and 4.9 billion gallons per year of SAF may be produced by 2030, creating a clear pathway to achieve the SAF Grand Challenge near-term goal.[2]
- This volume is predominantly renewable diesel (RD) capacity that could be shifted to SAF under favorable policy and market conditions.
- Historically, very little RD production has shifted to SAF production. The Commercial Aviation Alternative Fuels Initiative (CAAFI), a joint venture between DOT's Federal Aviation Administration (FAA) and the commercial aviation industry, is tracking more than 2 billion gallons per year of domestic SAF production intent by the end of 2028 and is working with 200 potential SAF producers on their commercialization planning efforts.

Key assumptions:

- A project success ratio of 0.5 is applied to active RD and SAF projects.[3]
- The low scenarios include the potential SAF distillate cut from active projects.
- The high scenarios add a higher SAF distillate cut achievable with additional equipment upgrades and operating expense.[4]

[1] Active projects are RD and SAF projects that are either currently producing, in construction, or announced and proceeding with development. To be included, projects must have a publicly announced start date, conversion technology, and capacity.

[2] No new projects have been announced with start dates later than 2028.

[3] The project success ratio, calculated from historic data, is used to estimate the number of active projects expected to successfully produce RD and/or SAF. An average project success ratio of 0.5 has been derived based on a historical database of RD and SAF projects, and was applied to all active RD and SAF projects not currently in production. A project success ratio of 1.0 was applied to actively producing projects, as well as all announced coprocessing projects, as they are assumed to have a high implementation rate.

[4] SAF low and high potential scenarios are based on 40% and 80%, respectively, of total HEFA distillate volume redirected to SAF.

Applicable RDD&D Projects

Since the SAF Grand Challenge was announced in September 2021 the Federal agencies have administered the following programs to support the SAF enterprise through September 2024:

- DOE Bioenergy Technologies Office (DOE-BETO) has awarded $151 million in funding for 28 pre-pilot-, pilot-, and demonstration-scale projects. This includes one SAF commercial deployment project. This funding is leveraging an estimated $156 million in private sector funding.
- USDA provided $18 million in funding from the Agriculture and Food Research Initiative Sustainable Agricultural Systems program for the development of three integrated supply chain projects, as well as $30 million for a SAF commercial deployment project. This funding is leveraging an estimated $175 million in private sector funding.
- The FAA has invested $5 million in the ASTM fuels clearinghouse. Two new pathways have been approved, and eight are currently at various stages of the approval process. This is leveraging an estimated $100 million in private sector funding.
- The FAA announced awards totaling $249 million to advance the deployment of SAF through the Fueling Aviation's Sustainable Transition (FAST) program. This funding was made possible by the Inflation Reduction Act of 2022 and is expected to leverage at least $83 million in private sector funding.

Roadmap Progress by Action Area

Feedstock Innovation

USDA

- The Partnerships for Climate-Smart Commodities awarded more than $3 billion in new public–private partnerships promoting climate-smart agricultural and forest practices. Many of these projects could impact SAF feedstock availability and sustainability. Four awards specifically address SAF feedstock production, availability, and sustainability ($175 million).
- The National Institute of Food and Agriculture's Agriculture and Food Research Initiative – Sustainable Agricultural Systems distributed three awards ($18 million) for system-based projects involving public–private partnerships conducting research, demonstration, outreach, and education to enable commercial production of biofuels and biobased products. This is also relevant to the Building Supply Chains Action Area.
- The National Institute of Food and Agriculture's Agriculture and Food Research Initiative – Foundational and Applied Sciences distributed six awards ($3.14 million) for biorefining, feedstock development, and supply chain projects

involving fundamental and applied research, outreach, and education to advance the science of aviation fuel production from biobased feedstocks and to enhance the contribution of bioeconomy.

- Funded $27,797,000 in Agricultural Research Service/Forest Service Regional Biomass Research Centers in Fiscal Years (FY) 2022–2023 across 12 projects supporting a broad range of genetic improvement, field evaluation, and supply chain logistics on biomass feedstocks.
- Released the Agricultural Research Service (ARS) Crop Production and Protection 10-year strategic plan for the U.S. National Plant Germplasm System, including genetic resources used to improve many crops used as feedstocks for SAF. ARS crop genetic and genomic databases served 41,000 unique researchers per month, providing functional information on a genome wide scale across crop plants and highly leveraged for SAF crops. The USDA National Plant Germplasm System, the foundation for continued crop improvement, distributed more than 250,000 seeds and clonal germplasm to researchers and breeders per year including crops for SAF.
- Published a biomass supply chain plan and implementation framework in response to Executive Order 14081– Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy.
    - Building a Resilient Biomass Supply: A Plan to Enable the Bioeconomy in America (usda.gov)
    - USDA Implementation Framework for A Plan to Enable the Bioeconomy in America: Building a Resilient Biomass Supply.

  The Biomass Supply Chain Plan and Implementation Framework underpin the SAF Grand Challenge Feedstock Innovation Action Area through six major actions:

    1. Develop the Next Generation of Biomass Feedstocks and Increase Use of Cover Crops
    2. Improve Access and Utilization of Woody Biomass for Biobased Products
    3. Invest in Resilient Infrastructure and Capacity to Utilize Biomass Feedstocks for More Jobs and Stronger Rural Economies
    4. Support New and Better Markets for Biobased Products that Drive Demand for Biomass Feedstocks
    5. Promote Climate-Smart Practices to Enhance Productivity and Sustainability of Biomass Feedstocks

6. Provide Stakeholder Outreach and Technical Assistance to Ensure the Resilience of Biomass and Biobased Supply Chains.

DOE–BETO

- DOE established the Regional Biomass Resource Hub Initiative, designed to accelerate the sustainable mobilization of purpose-grown energy crops to create clean fuels and products. BETO announced $29 million for the Regional Resource Hubs for Purpose-Grown Energy Crops funding opportunity announcement (FOA).
- Awarded three public–private partnerships focused on the feedstock–conversion interface ($2.18 million).
- Invested $15 million in upgrades to DOE's Biomass Feedstock National User Facility at Idaho National Laboratory.
- Funded $83 million in DOE national laboratory R&D, supporting terrestrial supply and preprocessing, feedstock–conversion interface activities, feedstock logistics R&D, and algae strain and process development.
- Awarded nine public–private partnerships focused on improving the production of environmentally sustainable and low-carbon feedstocks for bioenergy through climate-smart agricultural practices, as well as developing algae crop protection methods and strategies for algae cultivation systems ($23.6 million).
- Awarded $29.5 million for improved bioenergy resource recovery and conversion systems ($12.1 million for Renewable Carbon Resources topics in that FOA).
- Published the 2023 Billion-Ton Report, the fourth in a series of assessments of potential biomass resources available in the United States. The report explores these resources in terms of quantity, price, geographical density and distribution, and market maturity. Resource quantities in this report are limited by specified economic and environmental sustainability constraints.

FAA

- Funded $3.7 million at the FAA's Center of Excellence for Alternative Jet Fuels and Environment (ASCENT) for projects focused on feedstock market evaluation, soybean oil market impact, fire remediation, and hydrogen production support in partnership with USDA's Office of the Chief Economist and Forest Service.

Conversion Technology Innovation

USDA

- Agricultural Research Service (ARS) Regional Biomass Research Centers (see funding in the Feedstock Innovation section) are evaluating conversion of feedstocks. The four ARS utilization centers develop technologies that enable growth and profitability in support of the production of SAF as well as co-

products, which are important for SAF biorefineries to be economically feasible. See how the National Center for Agricultural Utilization Research is enabling conversion of agricultural waste into bio-oil that can be upgraded to SAF.

- ARS researchers work in collaboration with industry partners across the United States to develop novel conversion technology to produce biobased products and biofuels. ARS houses the world's largest collection of microbial species (ARS Culture Collection) critical to, and utilized in biorefining, along with the ability to genetically modify microbial species to address unique/difficult feedstock conversion issues.

DOE–BETO

- Funded $112 million in DOE national laboratory R&D supporting biological and thermochemical conversion technologies to improve efficiency, fuel yield, and cost. Notably, several new conversion pathways (hydrothermal liquefaction of organic waste, lignin hydrodeoxygenation, volatile fatty acid production, and others) have completed early fuel testing analyses to demonstrate viability for SAF.
- Awarded $16.7 million in funding for five projects to overcome gasification and biochemical conversion barriers that will advance the production of affordable biofuels and biochemicals to significantly reduce GHG emissions.
- Awarded five public–private partnerships to address robustness of biological and chemical catalysis pathways for the production of sustainable fuels ($12.5 million for conversion topics in that FOA.
- DOE partnered with the National Science Foundation to select three projects to accelerate biomanufacturing innovation and advance the U.S. bioeconomy ($1.93 million).
- DOE's Agile BioFoundry selected three projects in partnership with the MSI STEM Research & Development Consortium ($1 million).
- Awarded four projects under the Technology Commercialization Fund to advance lab-developed clean bioenergy technologies toward commercialization to reduce carbon intensity in the transportation, industrial, and/or agriculture sectors ($2.5 million).
- Announced the Clean Fuels & Products Shot™, a collaborative R&D initiative across DOE programs to reduce emissions from the fuels and chemicals industry by developing and utilizing sustainable sources of carbon.

DOE Advanced Research Projects Agency-Energy (ARPA-E)

- Awarded $41 million for 14 projects through its Grid-free Renewable Energy Enabling New Ways to Economical Liquids and Long-term Storage **(GREENWELLS)** program. GREENWELLS is the first time ARPA-E is

supporting renewable-to-liquid approaches to create liquid fuels/chemicals from waste gases like CO_2 and methane. Its objective is to develop systems that can economically store at least 50% of incoming intermittent renewable electrical energy into carbon-containing liquids like SAF.

DOT-FAA

- Through its ASCENT Center of Excellence, the FAA launched a new project 80 - Hydrogen and Power-to-Liquid Concepts for Sustainable Aviation Fuel Production. The primary goals of this project are to: 1) assess how hydrogen production and PtL production can be integrated with existing production and distribution infrastructure (existing infrastructure and SAF technologies) to produce fuels with lower carbon intensity, and 2) synthesize the information and obtain rules on combining carbon, hydrogen, and energy sources with different conversion technologies to improve environmental impacts and costs.

Building Supply Chains

DOE-Office of Clean Energy Demonstration (OCED)

- Clean hydrogen is an important input for all low-carbon intensity SAF pathways. OCED is providing $7 billion in funding through the Bipartisan Infrastructure Law for seven Regional Clean Hydrogen Hubs and ~$500M to support demand-side initiatives to scale the clean hydrogen sector.

DOE–BETO

- Awarded 28 integrated biorefinery projects that will accelerate production of biofuels at commercial scale. These included scale-up projects at the pre-pilot, pilot, and demonstration scale. BETO awards amounted to $151 million in 28 projects under Scale-Up and Conversion funding opportunities.
    - FY 2021: Awarded $33 million under the BETO Scale-Up and Conversion FOA for 11 integrated biorefinery projects.
    - FY 2023: Awarded $118 million in funding for 17 pre-pilot-, pilot-, and demonstration-scale projects under the Scale-Up+ FOA, including $10 million for four projects leveraging first-generation ethanol facilities to reduce carbon intensity scores.
    - Prior to the SAF Grand Challenge, DOE invested $123 million in 35 integrated biorefinery scale-up projects.
- Released five requests for information to solicit stakeholder feedback on key topics related to the advancement of bioenergy technologies across the supply chain to inform office strategic planning efforts. For example, in FY 2023 DOE released a request for information on building supply chains to meet SAF Grand Challenge goals.

- Coalition development is critical to building the supply chains necessary to achieve SAF Grand Challenge goals. The SAF Grand Challenge partners have led several events to convene diverse groups of stakeholders across the SAF supply chain. DOE has hired a consultant to assist in coalition development. Some key examples of initial efforts include:
    - DOE, along with the Port Authority of New York and New Jersey, hosted a workshop on financing for SAF and challenges and opportunities for the Northeast region (November 14, 2023).
    - DOE worked together with the Minneapolis Saint Paul Regional Economic Development Partnership (GREATER MSP) and Minnesota SAF Hub to host the SAF Economic Development Partnership Workshop on May 22–23, 2024, in Minneapolis.
    - Other regions and municipalities have expressed interest in working with the SAF Grand Challenge team to conduct similar workshops, including Seattle, Nebraska, and the U.S. Southeast and Mid-Atlantic regions.
    - Grassroots SAF coalitions have formed in Indiana, Illinois, and Kentucky since the announcement of the SAF Grand Challenge.
    - USDA and DOE participated in the Ag-SAF Summit to discuss regional feedstock production with large Midwest agricultural producers, trade associations, and state departments of agriculture (September 7, 2023).
- In collaboration with Argonne National Laboratory and Idaho National Laboratory, BETO is supporting workforce development and education through the introduction of the Bioenergy Research and Education Bridge Program (BRIDGES), an education curriculum based on case studies.
- Participated and presented at international events, engaging with stakeholders associated with initiatives such as the Clean Energy Ministerial, IEA Bioenergy Technology Collaboration Programme, Global Biofuel Alliance, Canadian Council for Sustainable Aviation Fuels, and other international efforts to ensure a global focus.
- Held a biorefinery siting workshop and community engagement event (January 30–31, 2024) to understand current practices and research on siting new energy infrastructure, and when possible, infrastructure related to bioenergy feedstock processing and refining and bioenergy distribution. BETO sought to identify knowledge gaps and opportunities for future research directions on siting bioenergy facilities, as well as more equitable bioenergy supply chains.

DOT–FAA

- FAA launched a new competitive grant program, Fueling Aviation's Sustainable Transition (FAST), made possible by the Inflation Reduction Act of 2022. The

grant program makes investments to accelerate the production and use of SAF and the development of low-emission aviation technologies to support the U.S. aviation climate goal to achieve net-zero GHG emissions by 2050. Under the SAF portion of the program, seven scoping studies related to infrastructure needs for SAF are being funded at a total of $1.7 million.

- FAA supports the DOT Volpe National Transportation Systems Center in the development of the Freight and Fuel Transportation Optimization Tool, designed to analyze the transportation needs and constraints associated with fuel and raw material (including biomass) collection, processing, and distribution in the continental United States. The tool is being increasingly used to analyze SAF supply chain scenarios and optimization.
- FAA, through ASCENT Project 01, Alternative Jet Fuel Supply Chain Analysis, is evaluating regional supply chains that could be used for SAF production including feedstock production, transportation, and fuel conversion. Researchers are evaluating fuel production pathways, feedstock and infrastructure requirements, and commercial fuel demand to create scenarios for future production. In addition, they are identifying potential intermediate materials and coproducts for each pathway to understand potential ways to aid in making biorefineries more economical.

Policy and Valuation Analysis

- The U.S. Department of the Treasury and the Internal Revenue Service, supported by the EPA, USDA, DOE, and DOT, issued guidance providing taxpayers with clarity and certainty on the SAF tax credit included in Section 13203 of the Inflation Reduction Act,
    - Notice 2023-6, released December 19, 2022, explains the requirements for the fuel to be eligible for the SAF tax credits, the various methods in which a claimant may claim the credit, and which parties must be registered for the different activities in the process.
    - Notice 2024-6, released December 15, 2023, provides a safe harbor for producers to determine the emissions reductions of SAF using the Renewable Fuels Standard (RFS). Under this guidance, numerous fuels qualify for the credit, including valid biomass-based diesel, advanced biofuels, cellulosic biofuel, or cellulosic diesel that has been approved by EPA under the RFS. This is in addition to fuels qualified under the International Civil Aviation Organization's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).
    - Notice 2024-37, released April 30, 2024, provides an additional safe harbor for producers using the 40BSAF-GREET 2024 model, which was developed by DOE in close coordination with the Treasury Department

and other agency partners. This Notice also establishes the USDA Climate Smart Agriculture Pilot Program, which enables SAF producers that source domestic corn and soybean feedstocks produced with certain climate-smart farming practices to further reduce the emissions reduction percentage calculated using the 40BSAF-GREET 2024 model for purposes of the SAF tax credit.

- Building on this work, USDA issued a request for information to collect input from the public on how to quantify and verify climate-smart farming practices for biofuels production in June 2024. This public comment period closed in July 2024. These public comments can inform the development of protocols for crediting climate-smart practices for SAF feedstock production.
- DOE and the National Renewable Energy Laboratory published a biofuel potential study in October 2023. The goal of the study was to evaluate the potential of biofuels to replace projected petroleum consumption in "hard-to-electrify" transportation sectors and reduce GHG emissions by 2050.
  - For the base case scenario, a total of 858 million tons/year of potential biomass supply is available. This could be converted into 55 billion gallons of gasoline equivalent per year of biofuel with the potential to reduce GHG emissions by 406 million tons/year.
  - For the expanded supply scenario, 1,279 million tons/year of potential biomass is available. This could be converted into 80 billion gallons of gasoline equivalent per year of biofuel with a GHG reduction potential of 644 million tons/year.

Enabling End Use

FAA

- The FAA announced award recipients for a new competitive grant program, FAST, made possible by the Inflation Reduction Act of 2022. The FAST grant program makes investments to accelerate the production and use of SAF, thereby supporting the goals of the SAF Grand Challenge, to meet U.S. aviation climate goals to reduce aviation carbon emissions. FAST supports the build-out of infrastructure projects related to SAF production, transportation, blending, and storage. A total of $242.8 million has been allocated among 15 projects that are related to SAF infrastructure development. Two SAF related projects were also funded under the FAST Tech category at a total of $4.5 million.
- FAA's ASCENT Project 031 supported multiple efforts to enabling end use, including qualification of two additional ASTM D7566 pathways[1] and one

[1] D7566 pathway additions include an additional Annex 5 pathway for the Global Bioenergies isobutene-to-jet synthetic paraffinic kerosene (IBN-SPK) pathway and a new Annex 8 for the Swedish Biofuels alcohol-to-jet synthetic paraffinic kerosene with aromatics (ATJ-SKA) pathway.

additional D1655 coprocessing pathway.[2] These additions were approved during the June 2023 meeting of the ASTM Aviation Fuels Subcommittee.

- FAA's Continuous Lower Energy, Emissions, and Noise (CLEEN) Program has ongoing efforts to support the 100% drop-in SAF ASTM D7566 standardization, as well as material compatibility evaluations for 100% drop-in SAF, with $3.1 million of funding.

Communicating Progress and Building Support

- The SAF Grand Challenge website has been launched under the Biomass Research & Development Board site. The website provides an overview of the SAF Grand Challenge Roadmap, recent news, and related resources by all three departments.
- Agencies have engaged with stakeholders to share information on the SAF Grand Challenge at more than 25 events since the roadmap release. For example:
  - FAA held a session, Fueling Aviation's Sustainable Transition via Sustainable Aviation Fuels (FAST-SAF), for the FAST program with key industry and research stakeholders (December 14, 2022).
  - USDA staff participated in sessions with large agricultural groups, forestry, and processors on the status of the SAF Grand Challenge, including a feedstock innovation/supply chain webinar (March 28, 2023).
  - USDA and DOE participated in the Biorenewables Symposium at Penn State (April 21, 2023).
  - DOE conducted a workshop on SAF and bioenergy feedstocks with the research community, with USDA participation (June 6, 2023).
  - USDA and DOE participated in an Ag-SAF Summit organized by large agriculture companies (September 7, 2023).
  - All three agencies provide updates via conferences (e.g., Advanced Bioeconomy Leadership Conference, Alternative Fuels and Chemicals Coalition Conference) and CAAFI webinars.
- More than 20 communication products, including press releases (e.g., DOE, DOT), blogs (e.g., USDA), articles (e.g., DOE, FAA), and a research video (USDA), have raised awareness of agency efforts on the SAF Grand Challenge.
- U.S. Government-supported research and policy analyses were showcased in the journal *Frontiers in Energy Research* as a research topic, with 26 papers by

[2] D1655 coprocessing pathway allows for coprocessing from hydroprocessed biomass.

U.S. Government, academic, and industry authors. This includes many contributions from FAA's ASCENT research program.

- USDA raised awareness of the SAF Grand Challenge through major stakeholder events such as the annual Agricultural Outlook Forum, USDA's oldest and largest annual gathering of key stakeholders from the agricultural sector. SAF was featured in a 2022 Agricultural Outlook Forum session on "Opportunities in the Biobased Economy."
- The SAF Grand Challenge has been incorporated into agency and governmentwide priority and strategy documents, including the USDA Strategic Plan, Fiscal Years 2022–2026; USDA Science and Research Strategy, 2023–2026; United States 2021 Aviation Climate Action Plan; U.S. National Blueprint for Transportation Decarbonization; Clean Fuels & Products Shot; and Bold Goals for U.S. Biotechnology and Biomanufacturing.

Sample of Private Sector Advances and Accomplishments to Advance the SAF Grand Challenge

- Airline intent continues to be demonstrated, with a continuing increase in the number of SAF offtake agreements (more than 70 to date) being defined worldwide.
- CAAFI, a joint venture between DOT–FAA and the commercial aviation industry, highlighted that they are working with more than 200 potential SAF producers on their commercialization planning efforts. Additionally, CAAFI is tracking more than 2 billion gallons per year of domestic SAF production intent by the end of 2028, providing some optimism toward achieving the 2030 production goal of 3 billion gallons per year. Several significant activities in the 2025–2030 time frame have yet to be commercially announced. This year (2024) should see a SAF/hydrogenation-derived renewable diesel production capacity expansion of approximately 400 million gallons per year, nearly a 14-times increase from 2023 usage. However, commercialization progress continues to be slow due to several factors:
    - Significant time lapse from final investment decision to entry into service due to a range of factors, including permitting, material availability, and investment funding.
    - Business cases that do not close without policy support, while support is also of insufficient magnitude or duration to cover the term of the loan.
    - Inability/reticence of airlines to pay significantly more for SAF without policy surety and level playing fields, especially with airlines continuing to have financial challenges and poor credit ratings.
    - A policy environment that continues to favor renewable diesel production versus SAF production from facilities that can produce both products.
- Private sector press releases document an increase in activity toward the SAF Grand Challenge:
    - Aviation leaders (including four North American carriers) add another facet of direct engagement to tackle CO_2 emissions—the Aviation Climate Task Force—so far announcing two funding programs coming directly from airline annual contributions.
    - First transatlantic flight by Virgin using 100% SAF. On November 28, 2023, Virgin Atlantic completed a transatlantic flight from London's Heathrow Airport to New York's John F. Kennedy International Airport using 100% SAF. The SAF used delivers CO_2 life cycle emissions savings of up to 70%.

As electric and hydrogen-based fuel options are still under development and unlikely to mitigate emissions from large commercial aviation for perhaps another 20 years, SAF is a sustainable drop-in fuel that can be used in flights today.

- United Airlines, along with other Airlines for America members, have pledged to work toward the SAF Grand Challenge goal to collectively make 3 billion gallons of SAF available domestically by 2030. United is a founding member of the Biden administration's First Movers Coalition, a collective of leading companies committing to purchasing low-carbon technologies in hard-to-abate sectors. This initiative is committed to a target of replacing at least 5% of conventional jet fuel demand with SAF that reduces life cycle GHG emissions by 85% or more compared to conventional jet fuel by 2030. United is a founding member of the Aviators Group, which is focused on advancing collaboration on demand signals for SAF and a member of the Clean Skies for Tomorrow initiative, a global, cross-value-chain coalition facilitating commercial-scale SAF production for broad adoption by 2030 through supply, demand, policy, and financial levers.
- GREATER MSP is a first-of-its-kind coalition launching in Minnesota to scale SAF with the urgency commercial aviation needs to reach net zero by 2050. Through the GREATER MSP Partnership, Bank of America, Delta Air Lines, Ecolab, and Xcel Energy have established the Minnesota SAF Hub—the first large-scale SAF hub in the United States. GREATER MSP is committed to:
  - Environmental and water stewardship at all points along the SAF value chain beginning with feedstock—not at the airport—and at every step of the SAF production process.
  - Producing affordable, low-carbon SAF by developing an integrated value chain that stretches from production source and processing to refining, blending, and use at Minneapolis-Saint Paul International Airport.
  - Fostering adoption of innovative solutions and technology breakthroughs to accelerate the SAF transformation journey and scale up commercial progress.
  - Supporting university and private sector research and collaboration to address scientific and technical hurdles associated with the commercially viable production of ultra-low-carbon SAF from regenerative agricultural inputs.
- Southwest Airlines launched a renewable ventures subsidiary to advance SAF and announced both a $30 million investment in LanzaJet and the acquisition of SAFFiRE Renewables, who is pursing the development and commercialization of lignocellulose conversion to ethanol and jet fuel.

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