FAA Efforts
Sustainable Aviation Fuel

Sustainable Aviation Fuels Grand Challenge Update

By: Dr. Jim Hileman
Chief Scientific and Technical Advisor for
Environment and Energy
Office of Environment and Energy
Federal Aviation Administration

Date: October 26, 2022

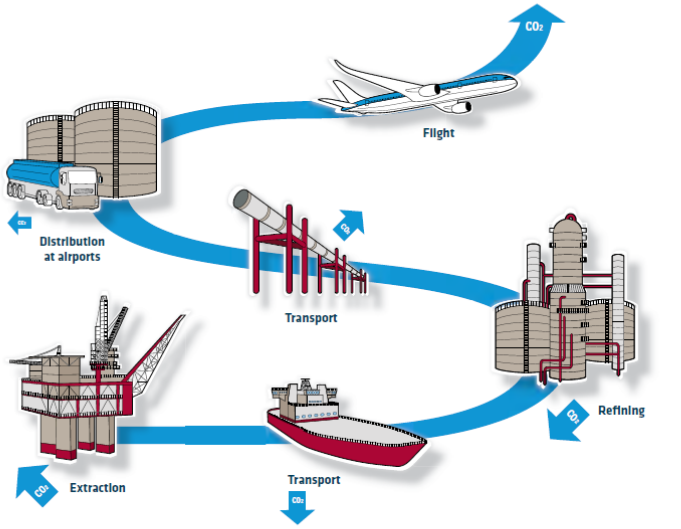
Benefits of Sustainable Aviation Fuels (SAF)

- **SAF are "drop-in" liquid aviation fuels –** same infrastructure, engines & aircraft
- **SAF can reduce lifecycle GHG and air quality emissions substantially** – critical to aviation de-carbonization
- **Viable technologies exist** – seven alternative fuel pathways currently approved for use, and two approved for co-processing with petroleum, more under evaluation for approval
- **Scalable feedstocks –** wastes & residues, biomass, sugars, oils and energy crops can all supply SAF
- **Widely accepted** by airlines, business, and general aviation
- **Broadly supported among federal agencies** as meeting critical goals - climate, energy security, rural economic development
- **Critical to international efforts** to address aviation emissions

Sustainable Aviation Fuels – Life Cycle Benefit

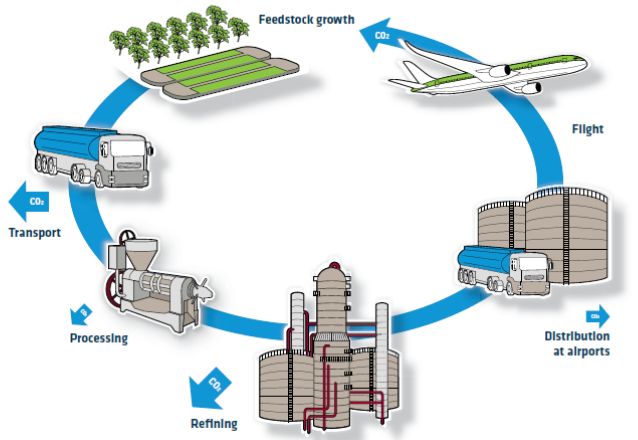
The extent to which any particular SAF provides a climate benefit depends on SAF's life cycle emissions profile, taking into account the production, transportation, and combustion of the SAF, as well as indirect effects.

Carbon lifecycle diagram: fossil fuels



At each stage in the distribution chain, carbon dioxide is emitted through energy use by extraction, transport, etc.

Carbon lifecycle diagram: Sustainable aviation fuel



Carbon dioxide will be reabsorbed as the next generation of feedstock is grown.
***Note:** the diagram above does not demonstrate the lifecycle process of SAF derived from municipal waste.*

FAA have extensive research that have supported development of rigorous life cycle accounting methods over the last decade:

- Argonne National Labs GREET Model
- ICAO Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)
- SAF Blenders Tax Credit (I.R.A. Sections 13203 and 13704)

Diagram from ATAG Beginner's Guide to SAF, which is available at:
https://aviationbenefits.org/downloads/beginners-guide-to-sustainable-aviation-fuel/

FAA SAF Program Focus

Testing
accelerate SAF development

- Test fuels
- Improve testing methods
- Conduct evaluation
- Streamline approval

Analysis
environmental and economic sustainability

- Lifecycle emissions
- Cost reduction
- Supply potential
- Supply chain opportunities

Coordination
support SAF integration

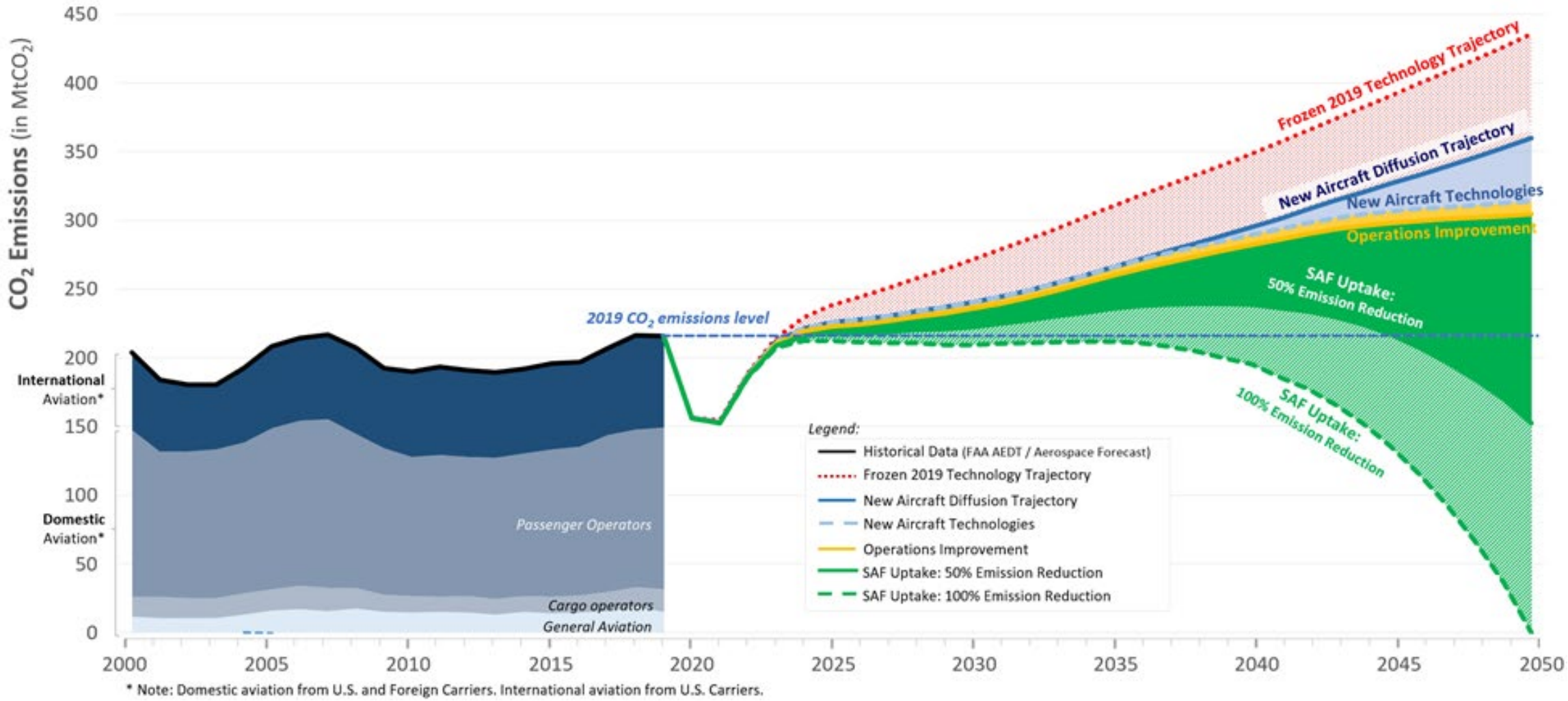
- Public-private partnership – *CAAFI*
- U.S. interagency cooperation
- International cooperation – *ICAO*

Aviation Climate Action Plan

- On November 9, 2021, Secretary of Transportation Pete Buttigieg announced the ***United States Aviation Climate Action Plan***, which describes a whole-of-government approach to put the aviation sector on a path toward achieving net-zero emissions by 2050.
- The plan builds on individual and sector-wide commitments announced by the U.S. aviation industry, and highlights specific actions and policy measures to foster innovation and drive change across the entire U.S. aviation sector.
- Key elements include:
  - Though "SAF Grand Challenge," goals of 3 billion gallons SAF produced per year by 2030 and 35 billion gallons annually by 2050 (100% jet fuel replacement).
  - Achieve a step-change improvement in environmental performance through NASA and FAA research, including Sustainable Flight National Partnership
  - More efficient air traffic operations
  - Improve scientific knowledge on non-CO_2 impacts
  - International action

https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf

Aviation Climate Action – Opportunities



NOTE: Analysis conducted by BlueSky leveraging FAA Aerospace Forecast and R&D efforts from the FAA Office of Environment & Energy (AEE) regarding CO2 emissions contributions from aircraft technology, operational improvements, and SAF

Federal Aviation Administration

SAF Grand Challenge

Multi-agency initiative: U.S. Departments of Transportation (DOT), Energy (DOE), and Agriculture (USDA) with Environmental Protection Agency (EPA)

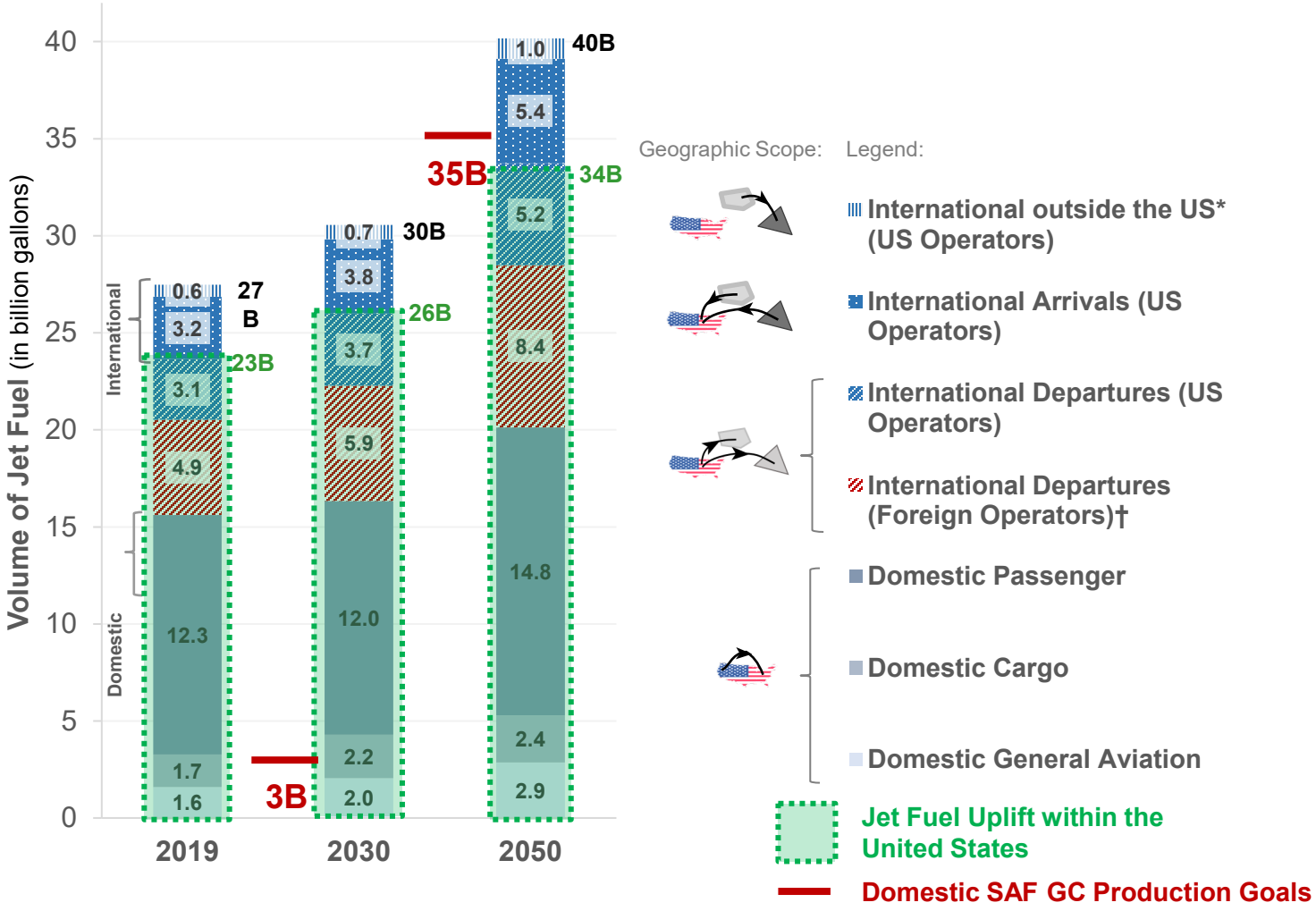
- **Commitment to:**
- **1) *leverage existing* government activities in research, development, demonstration, deployment, commercialization support, and policy;**
- **2) *accelerate new* research, development, demonstration, and deployment support; and,**
- **3) implement a *supporting policy* framework.**

- **In order to:**
  - ***Reduce cost***
  - ***Enhance sustainability***
  - ***Expand supply***

https://www.energy.gov/eere/bioenergy/articles/sustainable-aviation-fuel-grand-challenge-roadmap-flight-plan-sustainable

SAF Grand Challenge Goals Relative to Projected Demand

Sustainable Aviation Fuel Grand Challenge



** Flights between two different ICAO Member States (other than the United States) e.g., Germany -> UAE, UK -> China.*

† Not in scope of Climate Action Plan, shown to facilitate comparisons for SAF Grand Challenge.

Federal Aviation Administration

SAF Grand Challenge Roles

Sustainable Aviation Fuel Grand Challenge

DOE

- Continue investments and develop expertise in sustainable technologies to develop cost effective low carbon liquid fuels and enabling coproducts from renewable biomass and waste feedstocks
- Continue a significant multi-year SAF scale-up strategy committed to in FY21
- R&D aimed at creating new pathways toward higher SAF production
- Advance environmental analysis of SAF
- Collaborate with EPA to expedite regulatory approvals of SAF with significant life-cycle GHG reductions

DOT/FAA

- Develop overall strategy to decarbonize aviation
- Coordinate ongoing SAF testing and analysis
- Work with standards organizations to ensure safety and sustainability of SAF
- Continue International technical leadership
- Promote end use of SAF
- Support infrastructure and transportation systems that connect SAF feedstock producers, SAF refiners, and aviation end users
- Collaborate with EPA to expedite regulatory approvals of SAF with significant life-cycle GHG reductions

USDA

- Continue investments and build expertise in sustainable biomass production systems
- Decarbonize supply chains
- Invest in bio-manufacturing capability & workforce development
- Community and individual education
- Provide outreach & technology transfer to producers, processors and communities to accelerate adoption and participation
- Commercialization support
- Collaborate with EPA to expedite regulatory approvals of SAF with significant life-cycle GHG reductions

https://www.energy.gov/sites/default/files/2021-09/S1-Signed-SAF-MOU-9-08-21_0.pdf

Federal Aviation Administration

SAF Grand Challenge Roadmap

Sustainable Aviation Fuel Grand Challenge

- **Define what needs to be done in next decade**
  - to achieve a goal of 3 billion gallons of domestic SAF production in 2030 and put U.S. on trajectory to 35 billion gallons per year by 2050
- **Create a multi-agency plan for continuing, long-term, substantial federal assistance to:**
  - research and development activities
  - demonstration & deployment
  - commercialization support
  - workforce development
  - outreach/technology transfer
  - policy analysis
- **Released at the Global Clean Energy Action Forum on September 23, 2022**
  - https://www.energy.gov/eere/bioenergy/articles/sustainable-aviation-fuel-grand-challenge-roadmap-flight-plan-sustainable

SAF Grand Challenge Roadmap

Sustainable Aviation Fuel Grand Challenge

- **Six Action Areas**
  1. Feedstock Innovation (FI)
  2. Conversion Technology Innovation (CT)
  3. Building Supply Chains (SC)
  4. Policy and Valuation Analysis (PA)
  5. Enabling End Use (EU)
  6. Communicating Progress and Building Support (CP)
- **26 Workstreams**
- **139 Activities**
- **Now-2030 & 2030-2050 timeframes**
  - subset of key actions highlighted

SAF GC Roadmap – Action Areas

Sustainable Aviation Fuel Grand Challenge

1. **(FI) Feedstock Innovation** – Support and conduct R&D on sustainable feedstock supply that enables system innovations across the range of SAF-relevant feedstocks and identify optimization to reduce cost, technology uncertainty, and risk; increase yield and sustainability; and optimize SAF precursors (e.g., ethanol and isobutanol).

2. **(CT) Conversion Technology Innovation** – Support and conduct R&D, through pilot scale for technology improvements/carbon intensity reductions for both processes that are already commercial, or nearing commercialization and processes that will be ready for commercialization beyond 2030 but need to be developed now.

3. **(SC) Building Supply Chains** – Support SAF production expansion through supply chains, ensuring R&D transitions from pilot to large scale and field validation and demonstration projects, validating supply chain logistics, enabling public–private partnerships, supporting development of bankable business models, and collaborating with regional, state, and local stakeholders.

4. **(EU) Enabling End Use** – Facilitate the end use of SAF by civil and military users by addressing critical barriers, including efficient evaluation of fuel engine and aircraft performance and safety, advancement of certification and qualification processes, expansion of existing blend limits, and integration of SAF into fuel distribution infrastructure.

5. **(PA) Policy and Valuation Analysis** – Provide data, tools, and analysis to support policy decisions and maximize social, economic, and environmental value of SAF, including evaluation of existing and new policies.

6. **(CP) Communicating Progress & Building Support** – Engage stakeholder organizations, monitor and measure progress against SAF Grand Challenge goals, provide public information resources, and communicate benefits of the SAF Grand Challenge.

Support for 2030 & 2050 production

Workstreams Supporting Near-Term Production and Mid to Long-Term Innovation

Sustainable Aviation Fuel Grand Challenge

Workstreams Supporting Near-Term SAF Production Impactful to 2030 Goals

- **Build and support stakeholder coalitions through outreach, extension, and education** (Workstream SC.1) to set the stage for SAF supply chains to develop and sustain themselves and replicate with continuous improvement.
- **Maximize sustainable lipid supply for 2030** (Workstream FI.2) through a coordinated approach to lipid feedstock RDD&D to support rapid buildout of lipid pathway production.
- **Decarbonize, diversify, and scale current fermentation-based fuel industry** (Workstream CT.1) to address barriers to expansion of SAF supply via alcohol pathways.
- **Invest in SAF infrastructure** to support industry deployment (Workstream SC.4) and to allow industry to attract investment into production capacity.
- **Develop improved environmental models and data for SAF** (Workstream PA.1) to support optimization of existing policies and implementation of new policies that could be enacted.
- **Inform SAF policy development** (Workstream PA.3) with analysis of gaps and impacts of policies under consideration.
- **Stakeholder outreach and engagement on sustainability** (Workstream CP.1) to exchange data and information about best practices to reduce life cycle GHG emissions from agricultural and forest-derived feedstocks and optimize other environmental and social impacts.
- **Enable use of drop-in unblended SAF and SAF blends up to 100%** (Workstream EU.2) to simplify blending requirements, reduce cost of logistics, and facilitate supply.
- **Integrate SAF into fuel distribution infrastructure** (Workstream EU.4), including conducting infrastructure analysis to identify and address barriers to SAF supply to airports.

Workstreams Supporting Midterm and Long-Term Innovation Impactful to 2050 Goals

- **Conduct RD&D on scaling and sustainability of biomass, waste, and residue feedstocks** (Workstreams FI.3 and FI.6) to enable innovations in technologies and strategies that increase the availability of biomass and waste resources at reduced CI and cost. This includes addressing the social, environmental, and economic sustainability aspects of feedstock supply chains.
- **Conduct RD&D on feedstock logistics and handling reliability** (Workstreams FI.4 and FI.5) to increase efficiencies and decrease cost and CI of supply logistics from the producer's field to the conversion facility door.
- **De-risk scale-up through R&D and integrated piloting of critical pathways by 2030** (Workstreams CT.1–CT.4) to accelerate fuel conversion technology scale-up and improve financeability of critical conversion pathways that utilize the full potential of an expanded feedstock supply.
- **Build and support regional stakeholder coalitions through outreach, extension, and education** (Workstream SC.1) to continue to expand an SAF industry that improves environmental and economic performance while supporting job creation and social equity in multiple regions of the country.
- **Model and demonstrate sustainable regional supply chains for critical pathways by 2035** (Workstreams SC.2 and SC.3) to promote commercialization of SAF supply chains through process validation and risk reduction via access to critical data and tools that empower rapid, informed decision-making when evaluating SAF supply chain options.
- **Continue to invest in industry deployment** (Workstream SC.4) to help overcome barriers to project financing through creative financing, government loans and loan guarantees, and outreach.
- **Continue to inform SAF policy development** (Workstream PA.3) to enable aligned policy incentives that will support long-term SAF deployment.
- **Support SAF qualification** (Workstream EU.1) to accelerate fuel safety testing, evaluation, and specification activity; reduce the cost and time for new approvals; and expand the range of qualified fuels to include new critical pathways that will enable expansion of SAF supply.

Support for 2030 Production

Sustainable Aviation Fuel Grand Challenge

Workstreams with activities supporting Near-Term SAF Production Impactful to 2030 Goals

- **Build and support stakeholder coalitions** through outreach, extension, and education (Workstream SC.1) – **ASCENT, CAAFI**
- **Maximize sustainable lipid supply for 2030** (Workstream FI.2)
- **Decarbonize, diversify, and scale** current fermentation-based fuel industry (Workstream CT.1)
- Invest in **SAF infrastructure** (Workstream SC.4) – **IRA 40007**
- Develop **improved environmental models** and data for SAF (Workstream PA.1) - **ASCENT**
- Inform **SAF policy** development (Workstream PA.3) - **ASCENT**
- **Stakeholder outreach and engagement** on sustainability (Workstream CP.1)
- Enable use of **drop-in unblended SAF and SAF blends up to 100%** (Workstream EU.2) - **ASCENT, CLEEN**
- Integrate **SAF into fuel distribution infrastructure** (Workstream EU.4) – **ASCENT, IRA 40007, CAAFI**

Support for 2030-2050 Production

Sustainable Aviation Fuel Grand Challenge

Workstreams with activities supporting Midterm and Long-Term Innovation Impactful to 2050 Goals

- Conduct RD&D on **scaling and sustainability of biomass, waste, and residue feedstocks** (Workstreams FI.3 and FI.6)
- Conduct RD&D on **feedstock logistics and handling reliability** (Workstreams FI.4 and FI.5)
- **De-risk scale-up** through R&D and **integrated piloting** of critical pathways by 2030 (Workstreams CT.1–CT.4) -
- Build and support **regional stakeholder coalitions** through outreach, extension, and education (Workstream SC.1) - **ASCENT**
- Model and demonstrate **sustainable regional supply chains** for critical pathways by 2035 (Workstreams SC.2 and SC.3) – **ASCENT, Volpe**
- Continue to invest in **industry deployment** (Workstream SC.4)
- Continue to inform **SAF policy development** (Workstream PA.3) - **ASCENT**
- Support **SAF qualification** (Workstream EU.1) – **ASCENT, CLEEN, CAAFI**

ASCENT SAF Projects in Roadmap

Continuing

- **A001** Alternative Jet Fuel Supply Chain Analysis
- **A025** National Jet Fuels Combustion Program – Area #1: Chemical Kinetics Combustion Experiments
- **A031** Alternative Jet Fuels Test and Evaluation
- **A033** Alternative Fuels Test Database Library
- **A052** Comparative Assessment of Electrification Strategies for Aviation
- **A065A** Fuel Testing Approaches for Rapid Jet Fuel Prescreening
- **A065B** Fuel Testing Approaches for Rapid Jet Fuel Prescreening
- **A066** Evaluation of High Thermal Stability Fuels
- **A073** Combustor Durability Evaluation with Use of Alternative Jet Fuels
- **A078** Contrail Avoidance Decision Support and Evaluation
- **A080** Hydrogen and Power-to-Liquid (PtL) Concepts for Sustainable Aviation Fuel Production

New (FY22)

- **A087** Measurement of nvPM size, number and compositional emissions, for Boeing eco-Demonstrator aircraft burning SAF
- **A088** A Method for Rapidly Assessing Jet Fuel Compatibility with non-Metallic Materials
- **A089** Characterization of Compositional Effects on Dielectric Constant
- **A090** World Fuel Survey
- **A093** Collaborative Research Network for Global SAF Supply Chain Development

Inflation Reduction Act (IRA)

- **SAF tax credits**
  - Blenders Tax Credit (2023-2024)
  - Enhanced SAF value under Clean Fuel Production Credit (2025-2027)

- **Grant program (Section 40007)**
  - $244.5 million for projects relating to SAF production, transportation, blending, or storage
  - $46.5 million for projects relating to low-emission aviation technologies
  - $5.9 million to fund grant award program administration

Closing Observations

- We are taking a holistic approach to address aviation's impact on climate change
- SAF are central to this approach - critical to reducing CO_2 emissions from aviation in near, mid, and long term
- US Government committed to SAF production through the SAF Grand Challenge and are working with industry to scale up production with a near term goal of 3 billion gallons per year by 2030

CAAFI®
COMMERCIAL AVIATION ALTERNATIVE FUELS INITIATIVE

First flight from continuous commercial production of SAF
UAL 0708, 10 March 2016, LAX-SFO

Fuel from World Energy - Paramount (HEFA-SPK 30/70 Blend).

Only U.S. facility offering continuous production of SAF at present.
Other batch production & tolling occurring due to extreme customer interest.

Dr. Jim Hileman

Chief Scientific and Technical Advisor for Environment and Energy

Federal Aviation Administration
Office of Environment and Energy

Email: james.hileman@faa.gov