# ASCENT SAF Research Overview & Update

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ASCENT
AVIATION SUSTAINABILITY CENTER

# PRESENTATION OUTLINE

- Introduction to ASCENT
- SAF Research Strategies & Programs
- Inventory of Specific SAF Projects
- Emerging Program Support
- Questions & Discussion

# ASCENT Center of Excellence (COE)

**Lead Universities:**

Washington State University (WSU)

Massachusetts Institute of Technology (MIT)

**Core Universities:**

Boston University (BU)

Georgia Institute of Technology (Ga Tech)

Missouri University of Science and Technology (MS&T)

Oregon State University (OSU)

Pennsylvania State University (PSU)

Purdue University (PU)

Stanford University (SU)

University of Dayton (UD)

University of Hawaii (UH)

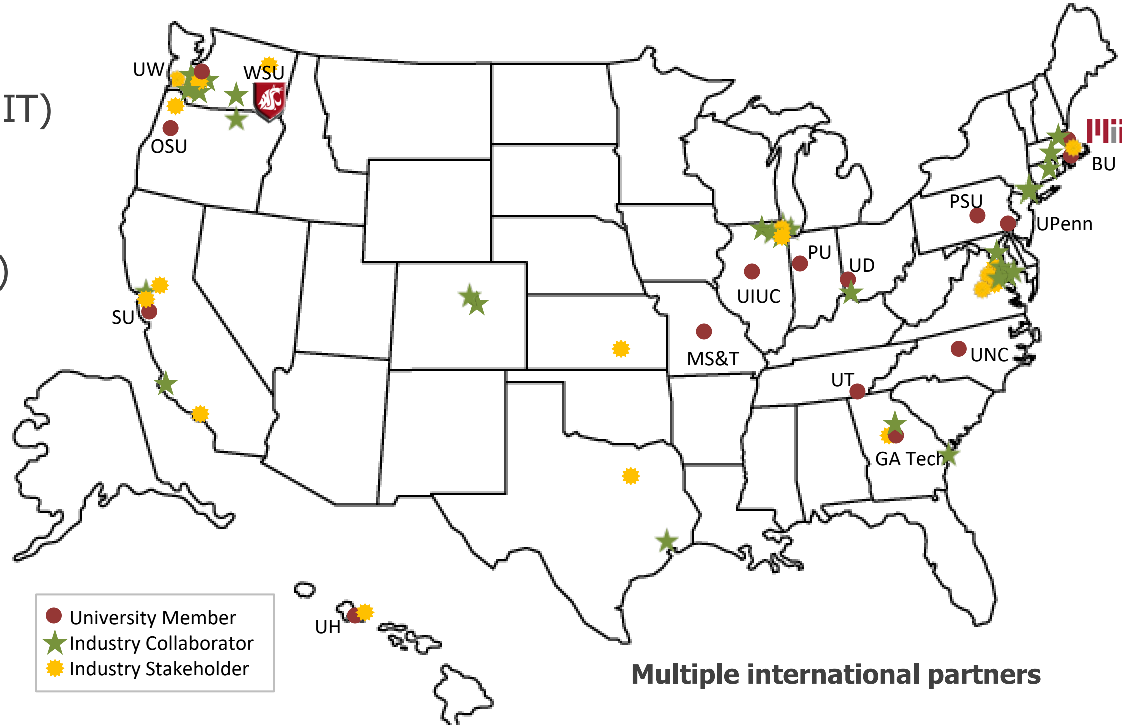
University of Illinois at Urbana-Champaign (UIUC)

University of North Carolina at Chapel Hill (UNC)

University of Pennsylvania (UPenn)

University of Tennessee (UT)

University of Washington (UW)




**Multiple international partners**

**For more information:** ascent.aero

**Advisory Committee - 57 organizations:**

5 airports
4 airlines
9 NGO/advocacy
8 aviation manufacturers
10 feedstock/fuel manufacturers
21 R&D, service to aviation sector

# ASCENT Mission

**FAA**
Environment & Energy

**ICAO** - International Civil Aviation Organization

**NOISE**

**AIR QUALITY**

**ENERGY**

# ASCENT Support & Coordination

Federal Aviation Administration

Transport Canada

NASA

Environmental Protection Agency

Defense Logistics Agency - Energy

U.S. Dep't of Energy

U.S. Dep't of Agriculture

Air Force Research Laboratory

**ASCENT COE:**

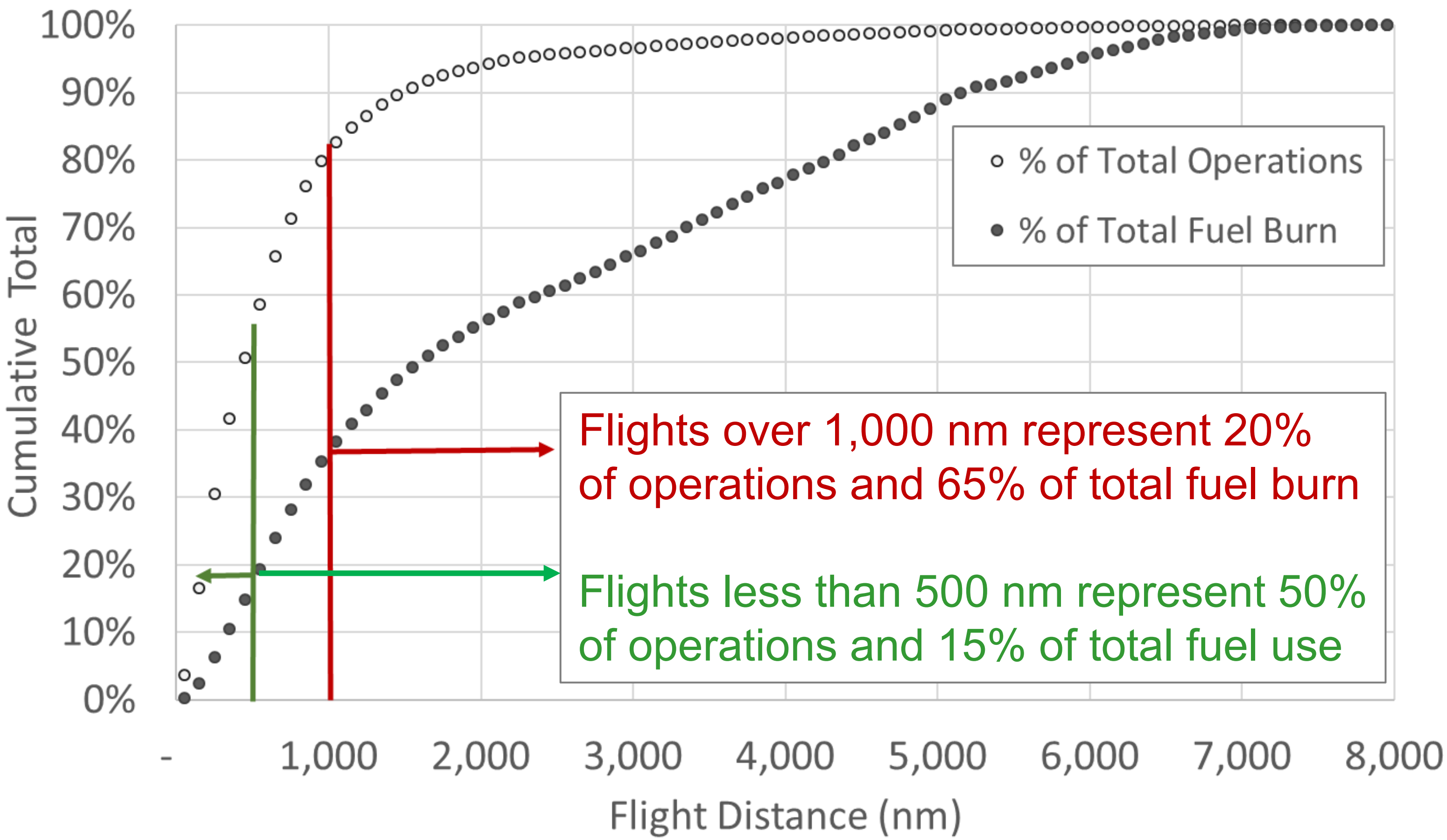
- In operation: 2013 to present
- $15M+ annual funding level
- $81.6M funding to date

**FAA COE research requires 100% cost share. This has led to significant collaboration among universities, industry, and international research programs**

# SAF Research Strategies & Programs

# Global Jet Fuel Use

- Global jet fuel use is driven by long-haul aviation
- SAF only option through 2050 for long distances



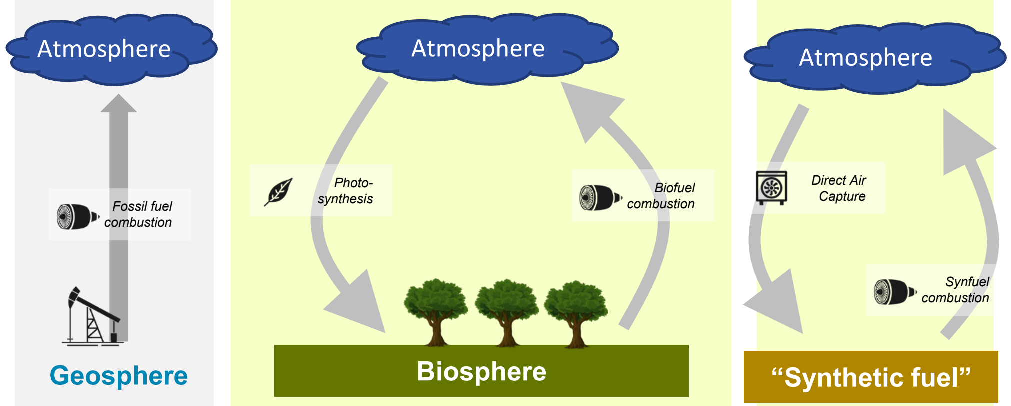

Data analysis conducted by the U.S. DOT Volpe Center using the Aviation Environmental Design Tool (AEDT)

# Energy Carriers for Aviation – A Typology

*Drop-in or near-drop-in SAF* | *Non-drop-in energy carriers*

| | Fossil Jet-A | Waste- and biomass-based SAF | Power-and-biomass-to-Liquid (PBtL) | Power-to-Liquid | Hydrogen | Battery ? |
|---|---|---|---|---|---|---|
| **H source** | *Fossil $H_2$* | *Biomass and wastes; currently supplemented by $H_2$ produced from SMR* | *Biomass feedstock and $H_2$ produced from renewable electricity* | *$H_2$ produced from low-carbon electricity* | *$H_2$ produced from low-carbon electricity or SMR with CCS* | |
| **C source & C balance** | *Fossil carbon* | *Biomass and waste streams** | *Biomass* | *Atmospheric $CO_2$ or waste $CO_2$ streams* | -- | |

*(Notional) change from current system*




* Using carbon from waste streams provides a carbon benefit if the carbon content of the waste stream would have been released to the atmosphere anyways.

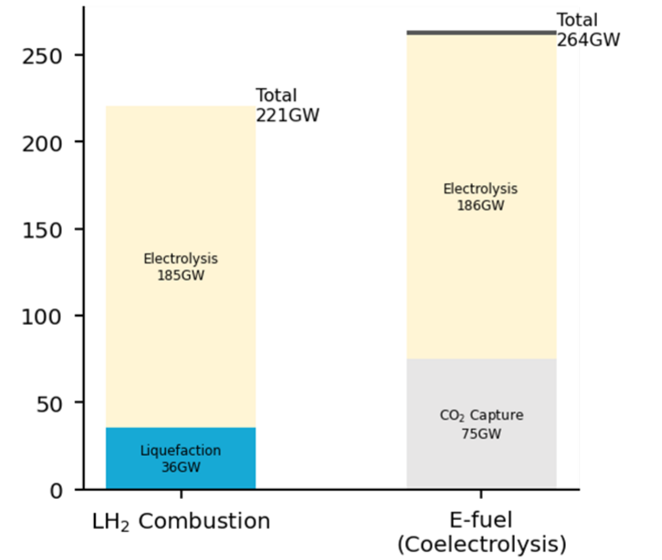
**Slide adapted from MIT LAE (Project 52/80), courtesy Florian Allroggen**

**Substantial Low Carbon Electricity Required for Hydrogen Production**

# Airports as Energy Hubs: Global picture

- Replacing jet fuel with cryogenic hydrogen would require considerable electricity to electrolyze water and compress it to a cryogenic state
- Power-to-liquids would require comparable energy as cryogenic hydrogen, but without requiring infrastructure changes

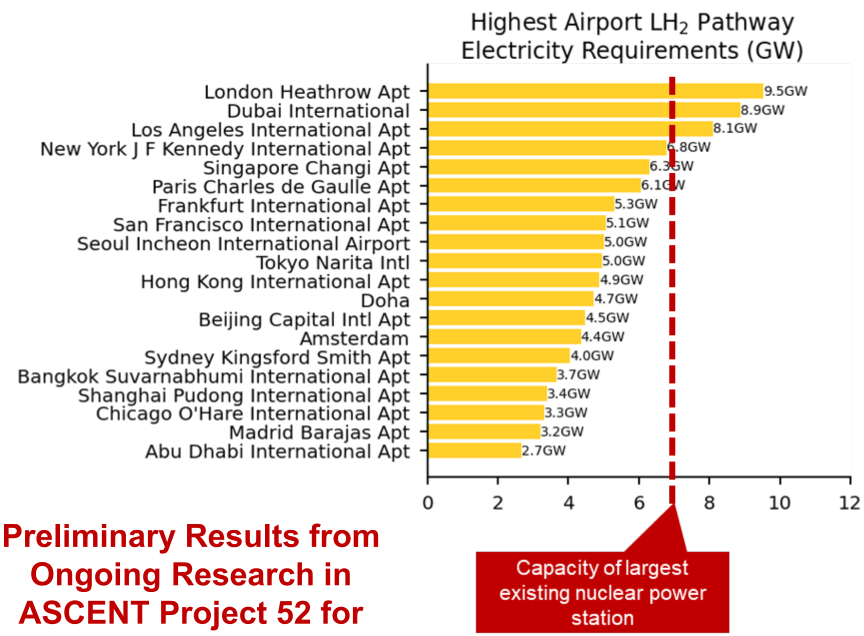
**Electric power consumption of fuel production**[1]
*broken down by process step, in GW*




[1] Values are annual average power demand.

**For comparison:**
U.S. power generation capacity (2019): 1.2 TW
Cumulative global PV capacity (2019): 627 GW

**Electric energy consumption of fuel production**
*in GW, by airport*




**Preliminary Results from Ongoing Research in ASCENT Project 52 for flights greater than 1,000 km**

**Graphic and data courtesy of MIT from ASCENT Project 52**

# Hydrogen Use in Aviation

MIT and WSU through A001 and A052 have been examining potential paths for using renewable electricity in aviation

*Hydrogen is the key to unlocking the potential of SAF*

- Using renewable hydrogen for fuel production would provide an immediate reduction in carbon footprint of aviation and enable the use of sustainable aviation fuels (low carbon fertilizers and fuel production)
- There are considerable waste and biomass resources in the U.S. that could be sustainably produced, at lower costs than either cryogenic hydrogen or power-to-liquids, and that would use today's infrastructure
- Makes logical sense to use these resources now and to leverage our current infrastructure. Could also use biomass with power-to-liquids.
- In the future, if we need more jet fuel than can be provided from waste and biomass resources, then power-to-liquid fuels could be a viable solution. It could be produced from renewable electricity via hydrogen as an intermediary while enabling us to use our existing infrastructure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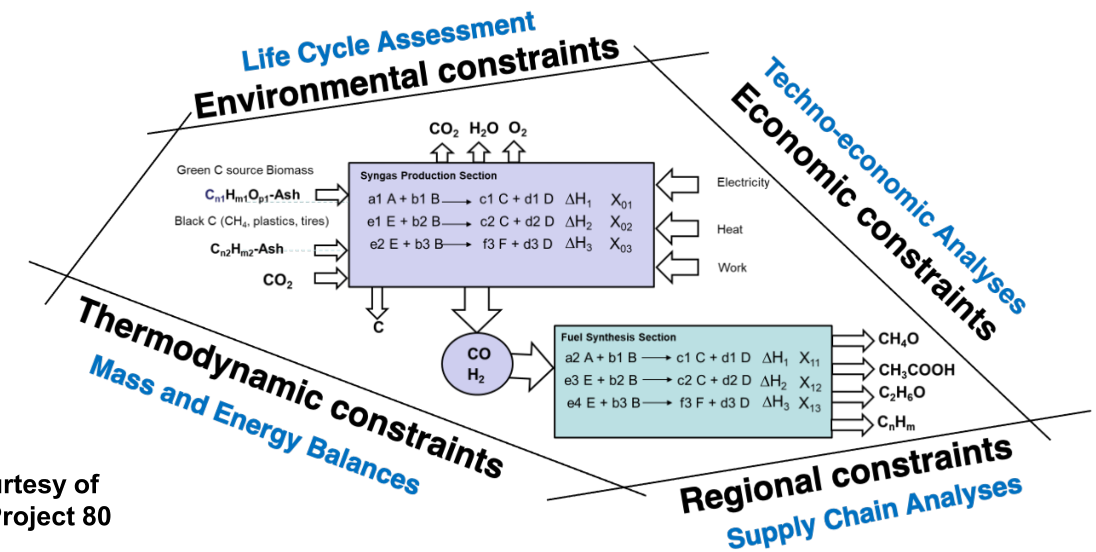
# Analysis: Novel SAF Production

***A080 will evaluate costs and lifecycle GHG for hydrogen, power-to-liquid (PtL) fuels, and how they can be integrated with biomass technologies***




**Graphic and data courtesy of WSU from ASCENT Project 80**

- Address recent interest in both green hydrogen and PtL concepts for aviation
- Intense electricity demand must be factored into lifecycle and techno-economic evaluations
- Provide recommendations for alternative uses and future directions as resource availability changes with time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# Testing/Certification/Qualification: Beyond 50%

*New ASCENT direction to support higher blend limits of alternative fuels*

- Current ASTM D7566 specifications limit most pathways to 50% by volume blending with conventional jet fuel
- Need to ensure fuels are drop-in compatible with existing and legacy systems
- Developing new ASCENT project(s) to isolate fuel properties that constrain blend volumes and develop fuel evaluations that support higher blend limits

# ICAO Fuels Task Group (FTG) and Long-Term Aspirational Goal Task Group (LTAG-TG)

- FTG working across five subgroups with a focus on maintaining the fuels-related sections of Annex 16 Vol IV (CORSIA).
- LTAG-TG working to inform 41st ICAO Assembly in October 2022 on feasibility of a long-term global aspirational goal for international civil aviation $CO_2$ emissions reductions.
- LTAG-TG Fuels Sub-Group focused on fuel production and lifecycle GHG emissions projections out to 2070.

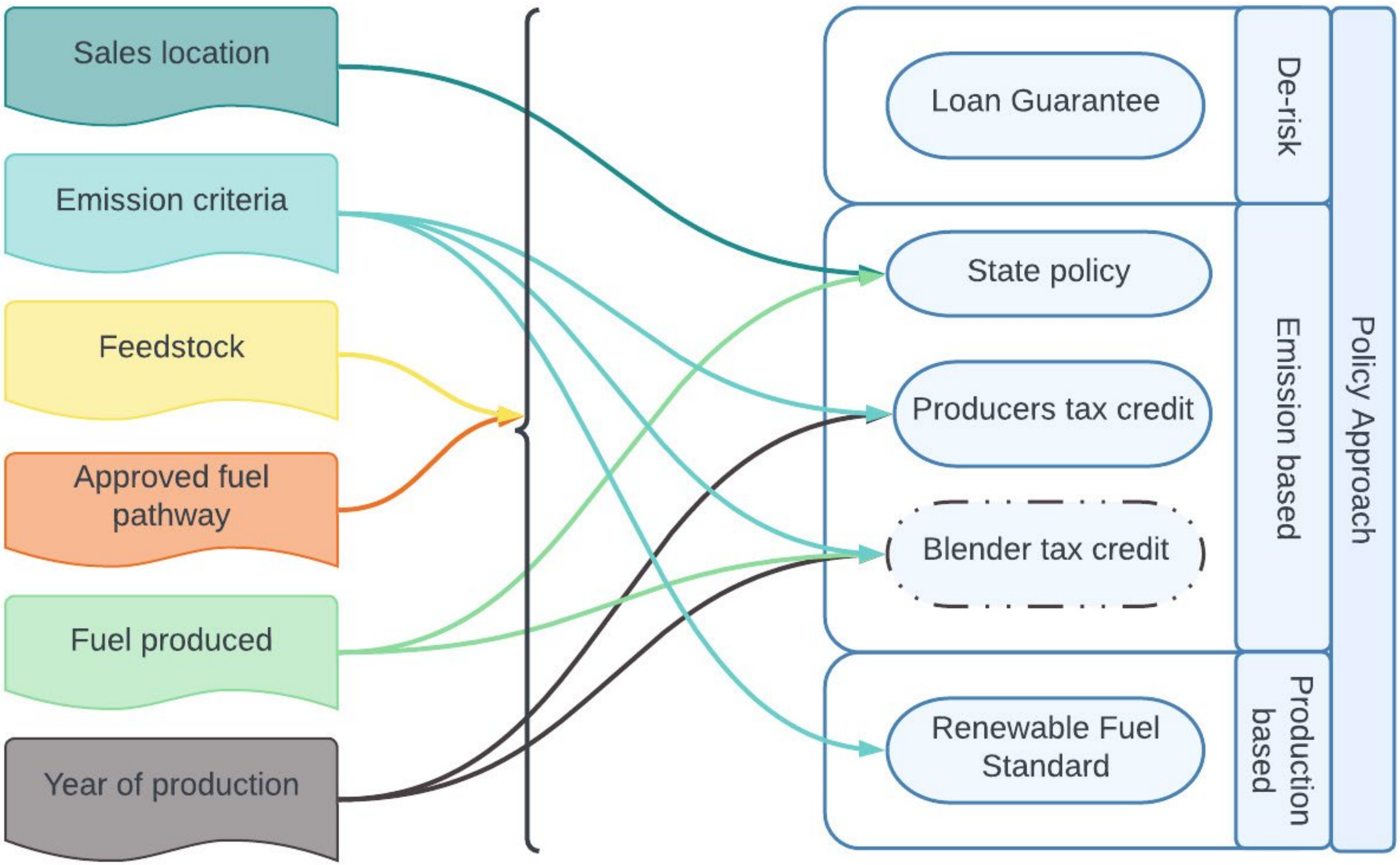
| Subgroup | Task Number | Task Title |
|---|---|---|
| ILUC | S.01.01 | Computation of induced land use change emissions for SAF for use in CORSIA |
| | S.01.02 | Low ILUC risk practices |
| | S.03 | Co-processing of esters and fatty acids in petroleum refineries – just ILUC calculation |
| | S.04.02 | Methodology refinements – ILUC |
| Core LCA | S.01.03 | Feedstocks classification |
| | S.02 | Computation of default core LCA emission values for SAF for use in CORSIA |
| | S.03 | Co-processing of esters and fatty acids in petroleum refineries – methodology for conducting LCA and default core LCA values |
| | S.04.01 | Methodology refinements – core LCA |
| Emission Reductions | S.04.03 | Methodology refinements – Emission Credits |
| | S.11 | Double counting |
| | S.12 | ILUC Permanence |
| All FTG | S.05 | CORSIA Package Updates |
| Sustainability | S.06 | Sustainability criteria |
| | S.07 | SCS Requirements |
| Technology and Production | S.08 | Technology evaluation |
| | S.09 | Fuel Production Evaluation |
| | S.10 | Guidance on Potential Policies and Coordinated Approaches for the Deployment of SAF |

# Lifecycle GHG Emissions and Sustainability

- FAA and ASCENT P01 / Volpe / ANL Team providing key data and leadership to determine how SAF and Lower Carbon Aviation Fuels (LCAF) are credited within CORSIA
- Continue to develop core life cycle emissions values for SAF made from waste CO emissions, jatropha, and co-processing of biomaterials with petroleum in today's refineries
- Continue to develop a life cycle analysis methodology for LCAF to determine fuel eligibility under sustainability criteria 1 and amount of crediting
- Sustainability criteria being developed for LCAF based on the list of SAF criteria – have also revised the SAF criteria
- Sustainability Certification Schemes have been approved by the ICAO Council and posted on the CORSIA Eligible Fuel website
- FAA continues to help convene a series of meetings with CAEP Members and Observers on LCAF to help overcome current impasse

For additional information on CORSIA Eligible Fuels
https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-Eligible-Fuels.aspx

# Policy & Support Analysis



# ASCENT/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*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# SAF Project Inventory

# SAF Production

## A001- Regional Supply Chain

Develop tools to assess the economic and environmental sustainability of SAF production in support:

- ICAO/CORSIA (FTG & LTAG)
- CAAFI & Regional supply chains

## A093- Global Supply Chain Evaluation

Work with international partners to make these tools globally relevant.

## A052-Electrification Strategies

## A080- H2 Use in SAF Production

Assess the role and potential of electrification strategies for SAF production.

# SAF Testing/Certification/Qualification

## A031- Clearing House Alternative Jet Fuel Test and Evaluation to Support the ASTM International Approval Process

In collaboration with industry, conduct combustion testing of novel drop-in jet fuels to ensure they are safe for use and conduct research to improve the certification process

## A025- Rapid Infrared Fuel Prescreening

## A065A/B- Rapid Prescreening Approaches

Examine novel methods for fuels prescreening to reduce the time and cost to ensure novel jet fuels are safe for use

# SAF Property Database

## A033- Alternative Fuels Testing Database Library

Establish a foundational database of information about current and newly emerging SAF

## A090- World Fuels Survey

Assess and catalog fuels produced globally

# SAF - Fuel/Engine Compatibility – 100% SAF

**A066- Evaluation of High Thermal Stability Fuels**

Testing high thermal stability fuels for emission reduction

**A67- Impact of Fuel Heading on Combustion and Emissions**

Evaluating fuel heating to optimize combustor efficiency

**A073- Combustor Durability Evaluation with use of SAF**

Conduct experiments to understand changes in combustor and turbine life with use of Alternative Jet Fuels with fuels that lack sulfur content and have reduced soot emissions.

**A088- Fuel Compatibility with Non-metallic Materials**

Develop a method to rapidly assessing the compatibility of candidate SAFs with non-metallic materials.

**A089- Compositional Effects on Dielectric Constant**

Examine how hydrocarbon composition affects the dielectric constant of a fuel, a key fuel property that aircraft use to determine the amount of fuel onboard an aircraft.

# Climate Projects

**A021- Improving Climate Analysis Tools (Completed in 2021)**

**A022- Evaluation of FAA Climate Tools**

Tool support to model the climate impact of aviation and support the Aviation Environmental Portfolio Tool (AMPT). Addresses impact of GHG and non-GHG impacts.

**A058- Improving Policy Analysis Tools to Evaluate Higher-Altitude Aircraft Operations**

**A083- Environmental Impacts of High Altitude and Space Vehicles**

Aimed at environmental impact of future aircraft technologies, especially supersonics and commercial space vehicles.

**A078- Contrail Avoidance Decision Support and Evaluation**

Understand contrail formation and development of persistent cloudiness.

# Emission Reductions & Measurements

**A039- Naphthalene Removal (Project Completed in 2021)**

Understand role of naphthalene removal for nvPM benefits in local air quality and contrails

**A018- Community Measurements of Aviation Emissions on Ambient Air Quality**

Evaluate the contribution of aviation sources to nvPM and other air pollutant concentrations in communities surrounding an airport.

**A002- Ambient Condition Correction for nvPM Emission Measurements**

**A081- Measurement and Prediction of nvPM size and number emissions from sustainable and conventional aviation fuels**

**A070- nVPM Reduction via Aero-Engine Fuel Injector Design**

**A087- Measurement of nvPM for Boeing Eco-Demonstrator burning SAF**

Understand how atmospheric conditions, engine design, and fuel composition (SAF & Conventional) influence nvPM production for emission improvements.

**A048- Analysis to Support Development of an Engine nvPM Standard**

Support for standards development around nvPMs

# Emerging Program Support

# SAF Grand Challenge Roles (in MOU)

## 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

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

# 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** – Suppo … improvements/carbon intensity reductions for b … commercialization and processes that will be rea … veloped now.
3. **(SC) Building Supply Chains** – Support SAF produ … nsitions from pilot to large scale and field validation and … enabling public–private partnerships, supporting develop … h regional, state, and local stakeholders.
4. **(PA) Policy and Valuation Analysis** – Provide da … imize social, economic, and environmental value of SA …
5. **(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.
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.

**ASCENT Projects either directly address or provide data to support every action area.**

Data & Analysis
Tools & Modeling
Testing & Methods

# FAA ASCENT & USDOT Volpe Center Support for FAST-SAF

**Technical support available to analyze potential SAF supply chains**

**Regional Supply Chain Configuration**

- Feedstock availability,
- Strategic plant siting,
- Optimal transportation solutions

**Performance Assessment**

- Basic conversion economics,
- Qualifying policy & support,
- Fuel characterization

# QUESTIONS