

# Sustainable Aviation Fuels (SAF)

## Update to FAA REDAC E&E Subcommittee

To: E&E REDAC Subcommittee

By: Nate Brown & Anna Oldani

Date: March 10, 2021



Federal Aviation  
Administration



# 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



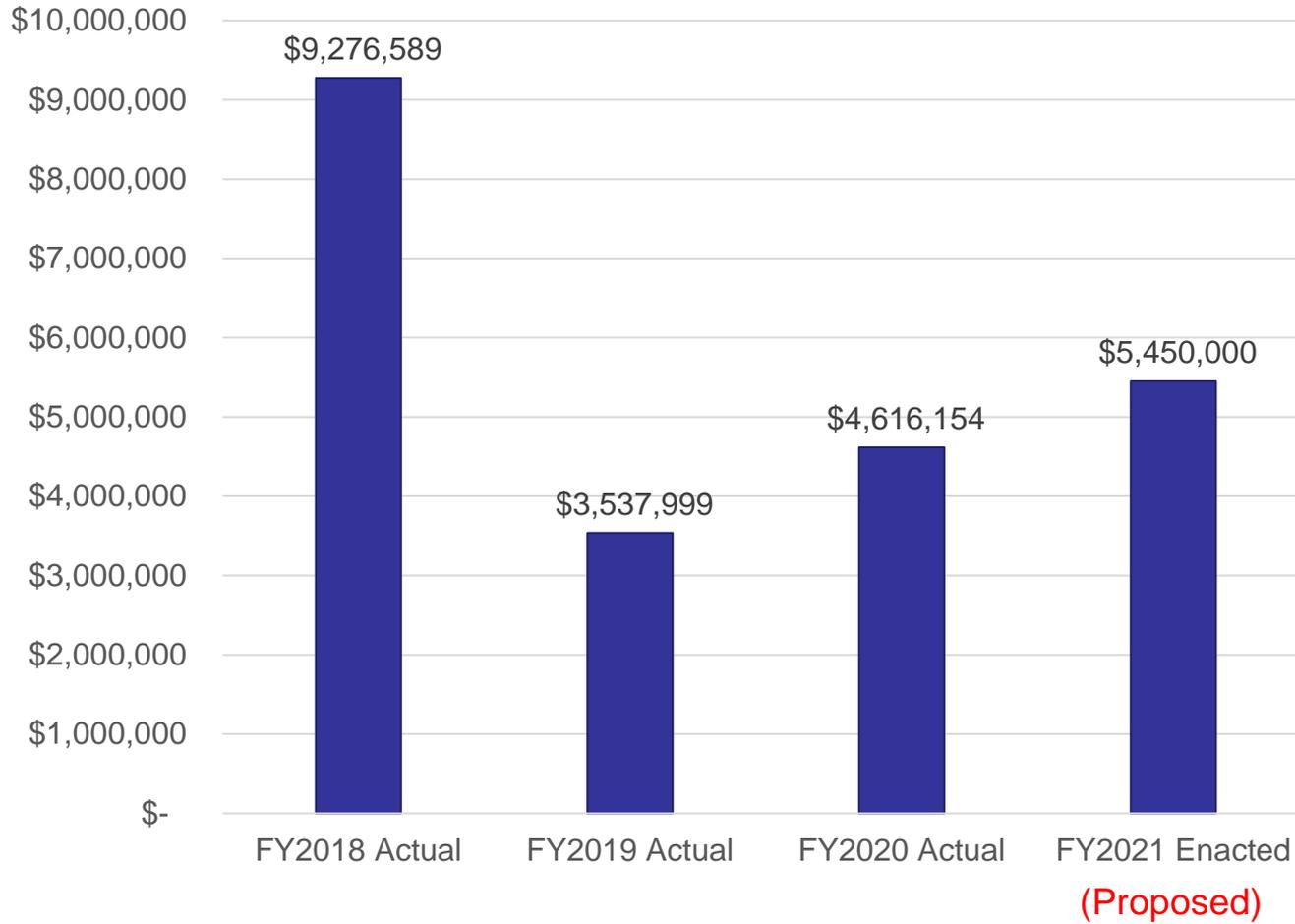
## Coordination

support SAF integration

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



# SAF Funding Levels



# Benefits of Sustainable Aviation Fuels (SAF)

- **SAF are “drop-in” liquid aviation fuels** – same infrastructure, engines & aircraft
- **SAF reduce GHG and air quality emissions substantially** – best near term path to aviation de-carbonization
- **Viable technologies exist** - seven alternative fuels currently approved for use, more under evaluation for approval
- **Scalable feedstocks** – wastes & residues, biomass, sugars, oils and energy crops can all supply SAF
- **Widely accepted** by airlines, business & 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



# Challenges to SAF to be addressed

- **Timely certification for aviation use of SAF solutions**
- **Increasing blend limits to greater than 50%**
- **Reducing the costs of production**
- **Expanding scale of production**
- **Availability of conversion infrastructure**
- **Availability of feedstock supply**



# Agenda

## Testing

- Qualification Process
- ASTM Status

## Analysis

- Supply Chain Tools & Analysis

## Coordination

- ICAO CAEP FTG & LTAG
- Federal
- Commercialization



# Agenda

## Testing

- **Qualification Process**
- ASTM Status

## Analysis

- Supply Chain Tools & Analysis

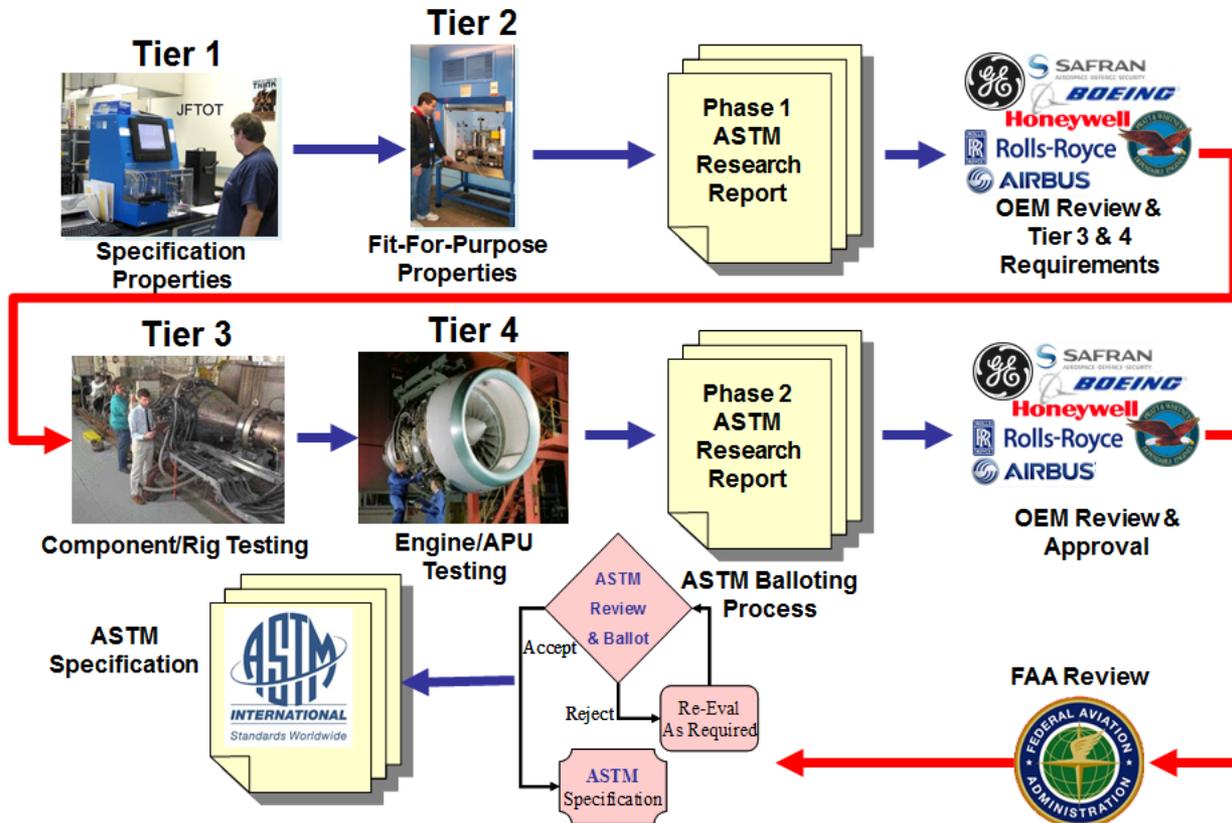
## Coordination

- ICAO CAEP FTG & LTAG
- Federal
- Commercialization



# Fuel Qualification – ASTM D4054

Multi-tiered qualification process involves stakeholders across industry and government

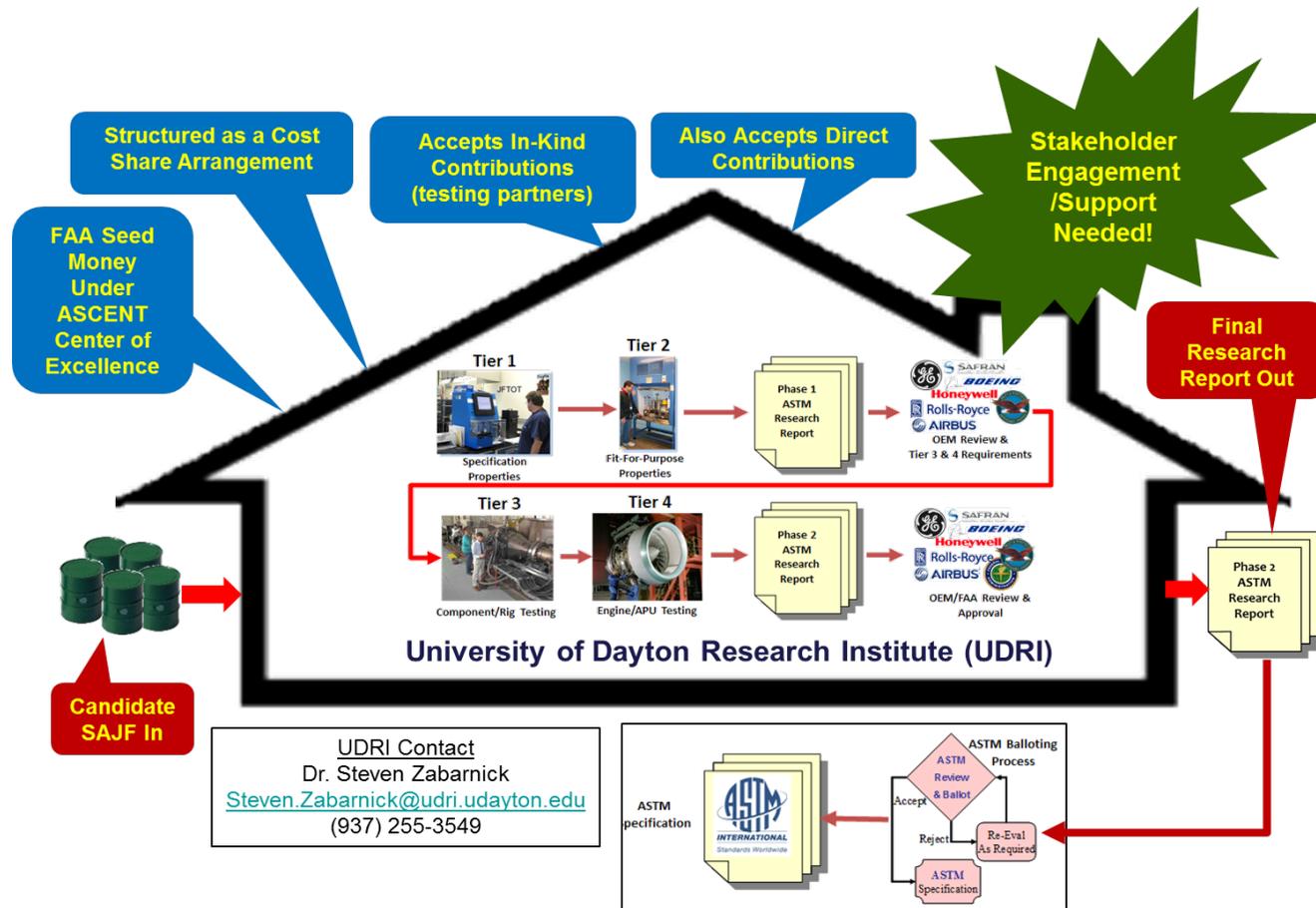


- **ASTM International** manages jet fuel specification
- **Does not determine sustainability** of fuel, only safety, performance
- **FAA and Defense** support evaluation of alternative fuels through:
  - *Clearinghouse*: certification & qualification testing
  - Data gathering & review
  - New test method development



# D4054 Clearinghouse

FAA Center of Excellence – ASCENT – facilitates centralized jet fuel testing through UDRI Clearinghouse



- Coordinating with EU and UK efforts to support and develop additional evaluation capabilities
- EU funding will support Clearinghouse testing (cost-share)



# Agenda

## Testing

- Qualification Process
- **ASTM Status**

## Analysis

- Supply Chain Tools & Analysis

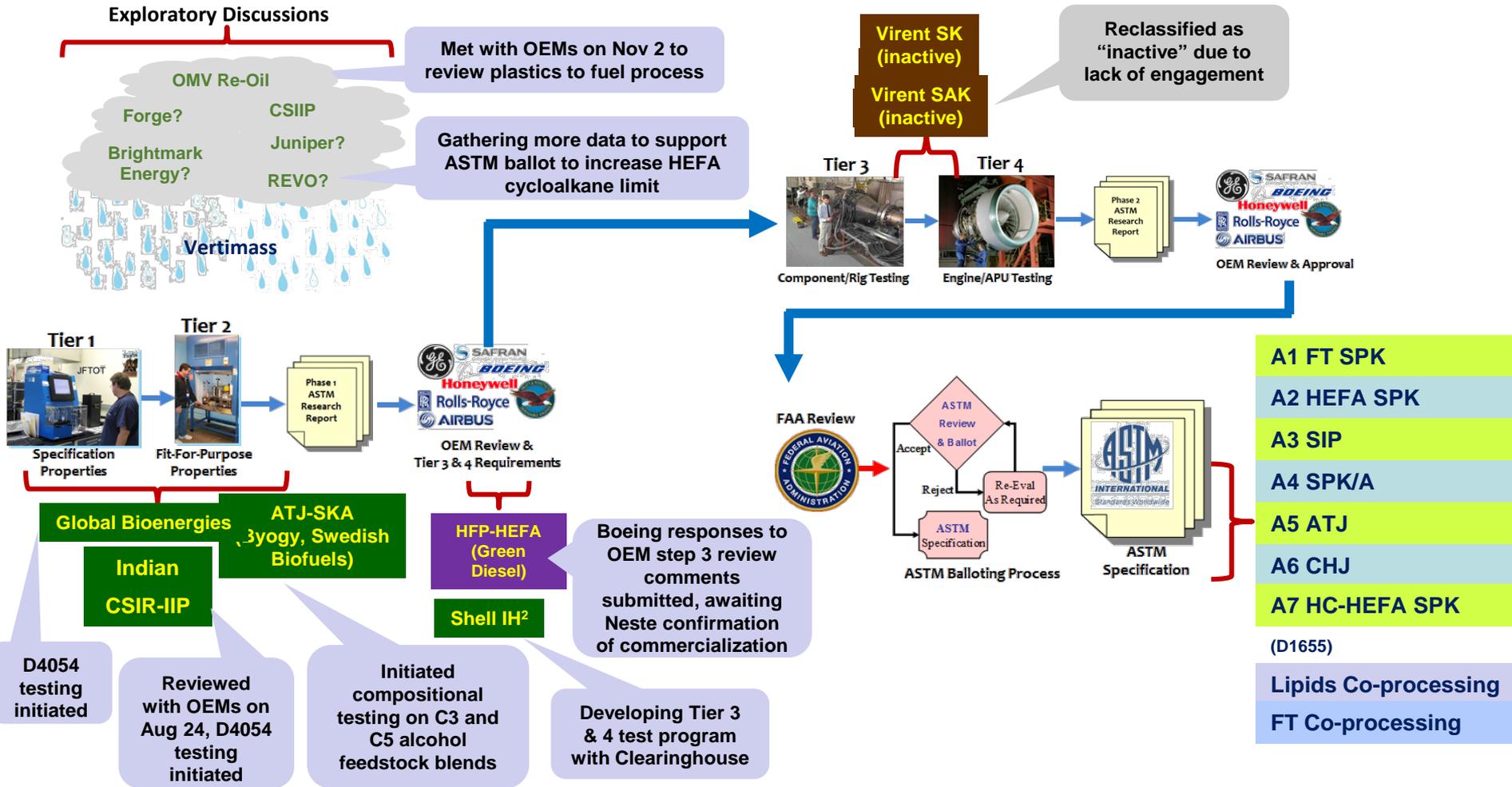
## Coordination

- ICAO CAEP FTG & LTAG
- Federal
- Commercialization



# ASTM D4054 SAF Qualification Status

Through FAA support, seven SAF categories have been annexed in ASTM D7566



# Reduce Fuel Approval Volumes

*As a result of the investments made by FAA and others, time and fuel volume requirements for ASTM International approval have fallen over time*

Fuel Type	ASTM Data Review	Final Phase II Report	ASTM Specification (D7566)	Estimated gallons of fuel produced for testing	Estimated time from first review to approval	Composition
FT-SPK	09/2007	09/2008	09/2009	710,000 <sup>1</sup>	3 years	Mostly normal/ iso-paraffins
HEFA-SPK	06/2008	05/2010	07/2011	626,000 <sup>2</sup>	3 years	
SIP*	06/2011	04/2013	06/2014	16,000	3 years	
Gevo ATJ-SPK (isobutanol)	12/2010	04/2015	06/2016	93,100 <sup>3</sup>	5 1/2 years	
Lanzatech ATJ-SPK (ethanol)	09/2016	07/2017	04/2018	50 <sup>4</sup>	1 1/3 years	
ARA CHJ	06/2012	10/2018	01/2020	79,000	7 years	Wider range of molecules
IHI HC-HEFA**	02/2019	06/2019	04/2020	50	~1 year	40% cycloparaffin

\*Approved at 10% volume

\*\*First Fast Track approval – approved at 10% volume blend limit

ARA – Applied Research Associates

<sup>1</sup>USAF fuel purchases in 2007-08 for fleetwide qualification

<sup>2</sup>USAF & Navy fuel purchases in 2009-11 for fleetwide qualification

<sup>3</sup>USAF, Navy and CLEEN fuel purchases in 2012-2014

<sup>4</sup>Only Tier 1-2 testing due to existing knowledge base and similarity to approved fuels



Federal Aviation  
Administration

# Beyond 50%

*Evaluate testing programs to support higher blend limits of alternative jet fuels*

- Recent conversations emphasize need for fuel evaluations to support higher blend limits
- Current ASTM D7566 specifications **limit most pathways to 50%** by volume blending with conventional jet fuel
- Seeking to **isolate fuel properties** which currently constrain fuel blend volumes
- Need to ensure fuels are **drop-in compatible with existing and legacy systems**



# Agenda

## Testing

- Qualification Process
- ASTM Status

## Analysis

- **Supply Chain Tools & Analysis**

## Coordination

- ICAO CAEP FTG & LTAG
- Federal
- Commercialization



# Analysis: Supply Chain Research & Tools

Understand benefits, costs and potential supply

- **Considering entire supply chain via analysis of:**

- Feedstock production
- Techno-economics of pathways
- Existing infrastructure
- Community assets
- Transportation routes and capacity
- Economic Impacts

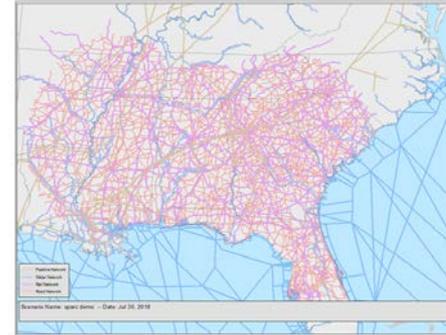
- **Three regional studies:**

- Inland Pacific Northwest
- Hawaii
- Southeast/Tennessee

- **Developing open source tools**

- FTOT; TEA models

- **Support for ICAO CAEP**



**Research Team:**

- ASCENT: Washington State U., MIT, Purdue, U. Tennessee, U. of Hawaii, Penn State U.
- U.S. DOT Volpe Transportation Center, DOE Argonne National Lab & National Renewable Energy Lab (NREL)

<https://ascent.aero/project/alternative-jet-fuel-supply-chain-analysis/>

<https://github.com/VolpeUSDOT/FTOT-Public>



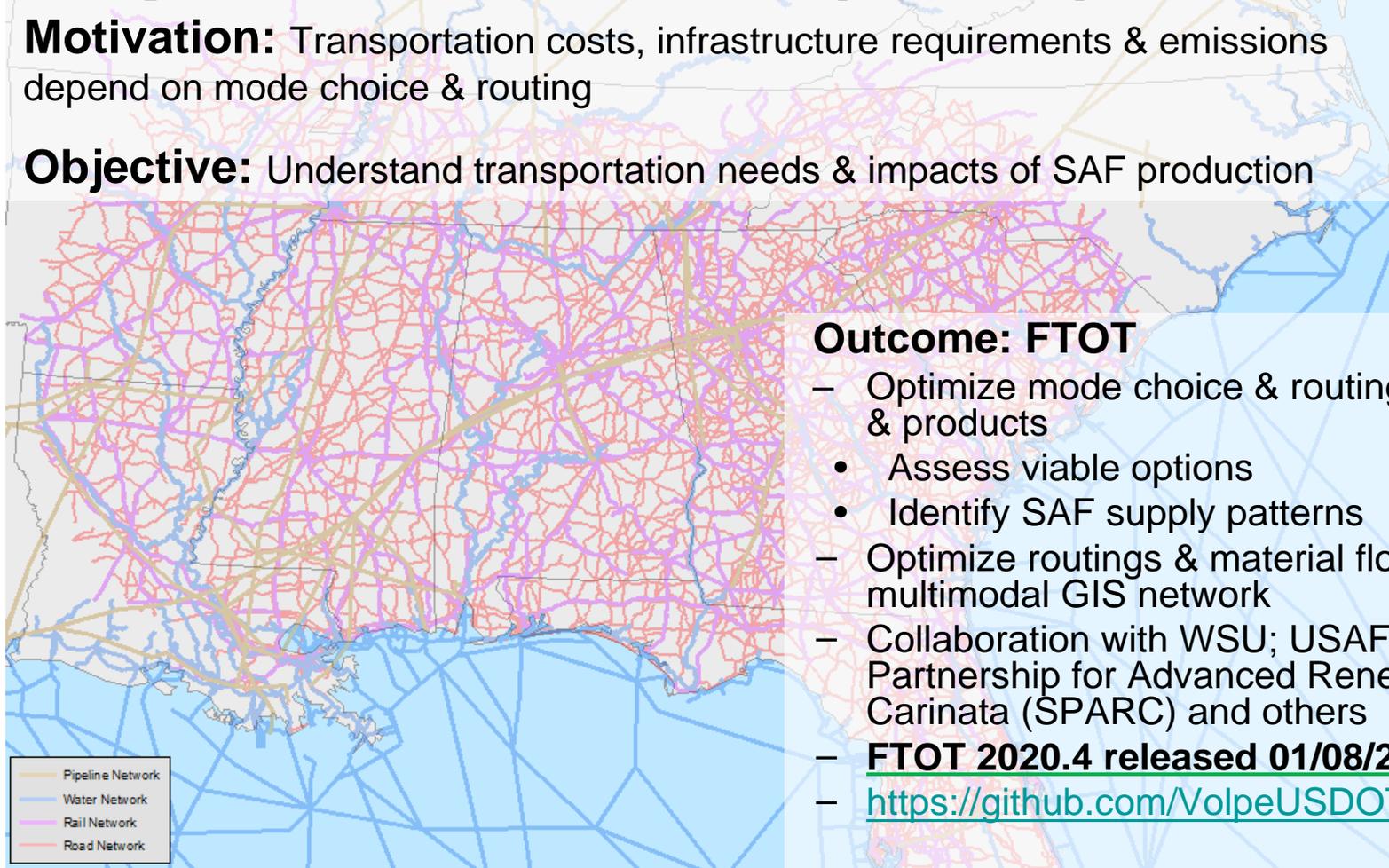
Federal Aviation  
Administration

# Freight & Fuels Transportation Optimization Tool (FTOT)



**Motivation:** Transportation costs, infrastructure requirements & emissions depend on mode choice & routing

**Objective:** Understand transportation needs & impacts of SAF production



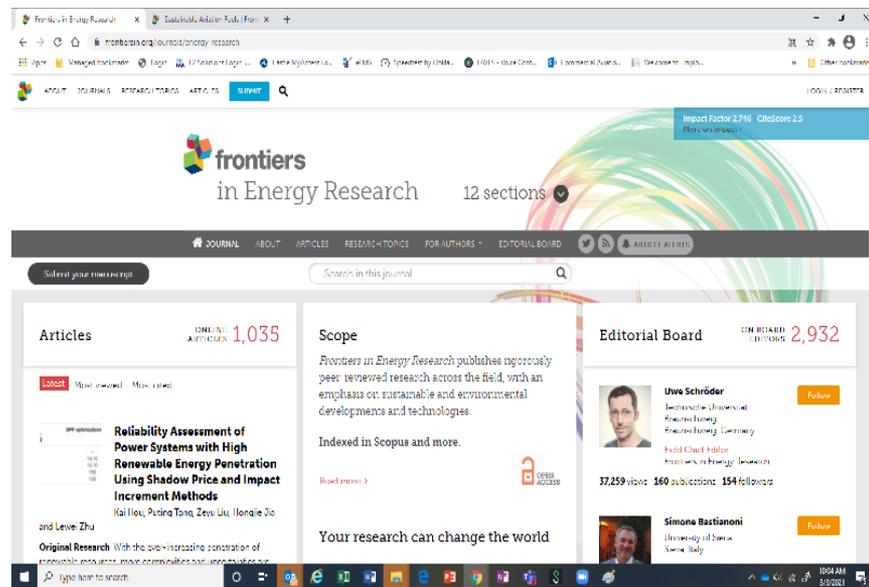
## Outcome: FTOT

- Optimize mode choice & routing of feedstocks & products
  - Assess viable options
  - Identify SAF supply patterns
- Optimize routings & material flow over multimodal GIS network
- Collaboration with WSU; USAF; Southeast Partnership for Advanced Renewables from Carinata (SPARC) and others
- **FTOT 2020.4 released 01/08/2021**
- <https://github.com/VolpeUSDOT/FTOT-Public>



# Frontiers in Energy Research SAF Topic

- **Online Journal**
- **SAF Research Topic**
  - Central point for SAF research
  - Make ASCENT 01 work visible
  - Open to other research
  - Variety of article types
- Feedstocks; Conversion; C/Q; Economics; Environment; Supply chain; Cost/risk reduction; & Policy
- **Editors:** WSU; FAA; DOE; USDA; Volpe; PNNL



# Agenda

## Testing

- Qualification Process
- ASTM Status

## Analysis

- Supply Chain Tools & Analysis

## Coordination

- **ICAO CAEP FTG & LTAG**
- Federal
- Commercialization



# Sustainable Aviation Fuels and CORSIA

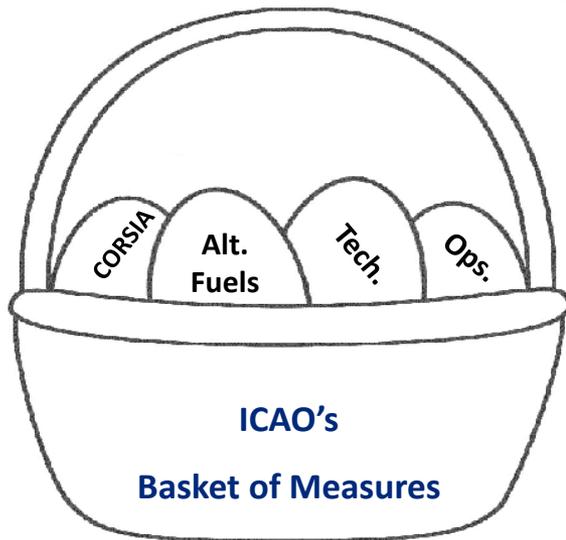


**CORSIA Eligible Fuels provide a secondary means to comply with CORSIA**

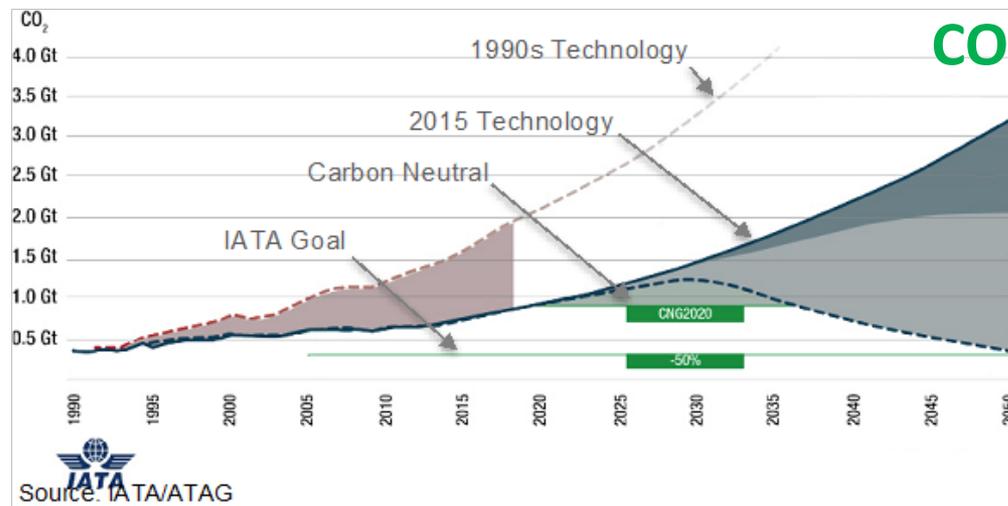
1. Offsetting
2. Claiming Emissions Reductions from CEF

$$ER_y = FCF * \left[ \sum_f MS_{f,y} * \left( 1 - \frac{LS_f}{LC} \right) \right]$$

Life cycle emissions value for a CORSIA eligible fuel



International Aviation Industry Carbon Goals



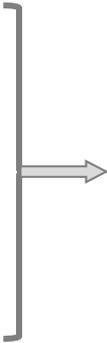
SAF and CORSIA are Key



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



- FTG working across five subgroups with a focus on maintaining the fuels-related sections of Annex 16 Vol IV (CORSA).
- LTAG-TG working to inform 41<sup>st</sup> ICAO Assembly in October 2022 on feasibility of a long-term global aspirational goal for international civil aviation CO<sub>2</sub> emissions reductions.
- LTAG-TG Fuels Sub Group focused on fuel production and life cycle 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
All FTG	S.12	ILUC Permanence
	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

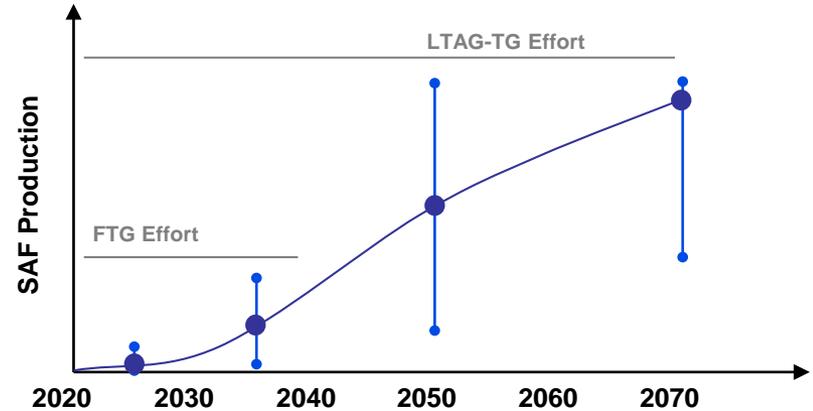


# Life Cycle GHG Emissions and Sustainability

- FAA and ASCENT P1 / Volpe / ANL Team providing key data and leadership that is determining how Sustainable Aviation Fuels and Lower Carbon Aviation Fuels are credited within CORSIA
- Much work ongoing 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
- Team also developing a life cycle analysis methodology for use with LCAF to determine fuel eligibility under sustainability criteria 1 and amount of crediting
- Sustainability Certification Schemes have been approved by the ICAO Council and posted on the CORSIA Eligible Fuel website
- Sustainability criteria are currently being developed for LCAF based on the list of SAF criteria
- FAA helped to convene a series of meetings with CAEP Members and Observers on LCAF to help overcome current impasse

# Future Fuel Production

- FTG & LTAG-TG have considerable ongoing work to project future SAF production – being led by FAA and ASCENT P1 / Volpe / ANL Team
- Team have assembled a global near-term SAF production database and are extending it to 2035-2050
- Team looking carefully at SAF production from waste CO/CO<sub>2</sub> gases and atmospheric CO<sub>2</sub>
- ASCENT P52 team are working to quantify infrastructure challenges associated with hydrogen use by commercial aviation
- Team considering fuel volumes, life cycle GHG emissions, investment requirements, etc.



Fuel Category	Fuel Types in Category
<b>Sustainable Aviation Fuels (SAF)</b>	Biomass-based fuel
	Solid and liquid waste-based fuels
	Gaseous waste-based fuels
	Atmospheric CO <sub>2</sub> -based fuels
<b>Lower Carbon Aviation Fuels (LCAF)</b>	Lower carbon petroleum fuels
<b>Non drop-in fuels</b>	Electricity
	Liquefied gas aviation fuels
	Cryogenic hydrogen



# Agenda

## Testing

- Qualification Process
- ASTM Status

## Analysis

- Supply Chain Tools & Analysis

## Coordination

- ICAO CAEP FTG & LTAG
- **Federal**
- Commercialization



# The Biomass Research and Development Board

## Leads the Bioeconomy Initiative

- Co-Chaired by DOE and USDA; at least one Board Member from each of 8 agencies
- Coordinate federal R&D activities relating to biofuels & bio-based products & their commercialization with collaboration between agencies
- Commercialization includes production at competitive prices via collaborations to enhance efficiencies along the entire bioenergy supply chain
- Assesses & provide strategic guidance regarding energy & environmental impacts
- Directs Board Operations Committee and interagency working groups (IWG)
  - SAF IWG established in July 2020 – co-chaired by FAA



# Biomass R&D Board



- The Sustainable Aviation Fuels Interagency Working Group (AAF IWG)
  - Ensuring aviation biofuel research and development efforts reflect critical needs
  - Advancing a revised and coordinated federal research and development roadmap on sustainable aviation fuels
  - Developing and scaling best practices to foster the success of sustainable aviation fuels in commercial, business, and military aviation sectors.
- Discussion of a SAF “Grand Challenge” within the Board.



# Federal Alternative Jet Fuels R&D Strategy - 2016

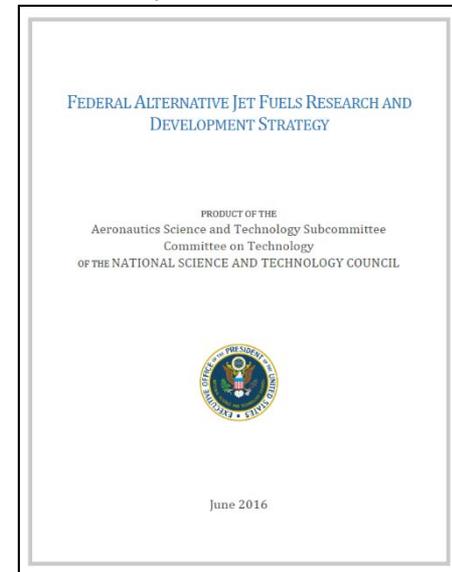
## Purpose

Enable the development, production, and use of environmentally sustainable, cost-competitive and socially responsible alternative jet fuel with stable supply to significantly meet the needs of U.S. jet aviation (released by White House OSTP June 2016)

## R&D Goals & Objectives

- Feedstock Development, Production, and Logistics
- Fuel Conversion and Scale-Up
- Fuel Testing and Evaluation
- Integrated Challenges

**8 participating Departments & Agencies: USDA, DOC, DOD, NASA, FAA, DOE, EPA, NSF, DOS**



[http://www.caafi.org/files/Federal Alternative Jet Fuels Research and Development Strategy.pdf](http://www.caafi.org/files/Federal_Alternative_Jet_Fuels_Research_and_Development_Strategy.pdf)



Federal Aviation  
Administration

# New initiatives?

- **Emphasis on transportation decarbonization**
- **Interest in SAF from leadership at DOT, DOE, USDA and others**
- **SAF a critical technology for aviation**



# Agenda

## Testing

- Qualification Process
- ASTM Status

## Analysis

- Supply Chain Tools & Analysis

## Coordination

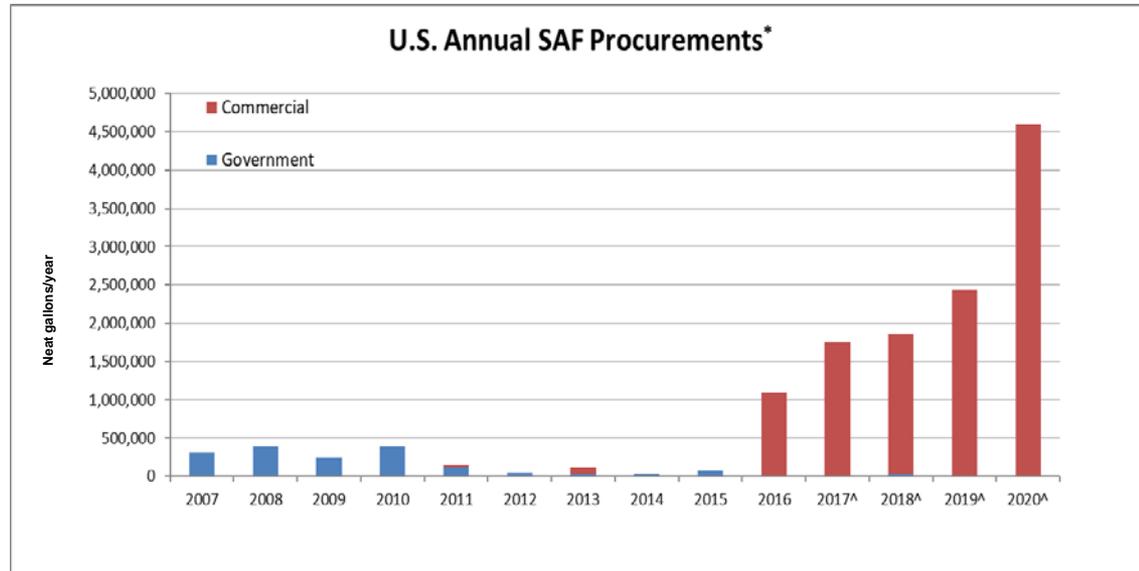
- ICAO CAEP FTG & LTAG
- Federal
- **Commercialization**



# Where we stand on U.S. SAF commercialization

Initiation under way, still early, but growing

- Five years of sustained & increasing commercial use
- 4.6M gallons in 2020 – 190% increase over 2019
- Commercial & General Aviation engaged
- Two facilities in operation
- Two facilities under construction, others in development
- Cost delta still a challenge, and renewable diesel favored
- New parties interested in SAF



\*Reflects voluntarily reported data on use by U.S. airlines, U.S. government, manufacturers, other fuel users, and foreign carriers uplifting at U.S. airports.

^ 2017-2020 calculation incorporates data reported by EPA for RFS2 RINs for renewable jet fuel.



Federal Aviation  
Administration

# Airline & Producer Offtake agreements

## Demonstration of broad airline industry commitment

		Up to 5 M gpy from 2016 (LAX)
		multi yr agreement 30/70 blend
		Misc Flights, e.g. SFO
		Bioports on demand, et al.
		Halmstad Arlanda Bromma Goteborg Leeuwarden
		37.5M gpy
		90-180 M gpy
		50 M gpy
		Project Development, License, and Offtake
		3 M gpy each, 7 yrs (Bay Area, CA)
		10M gpy, 10 yrs (JFK)
		4M gpy, 10 yrs (LAX)
		24M gpy, 10 yrs
		SAF Supply collaboration
		Supply from 2021
		UK DfT F&C Funding: ATJ Development

10 yr agreements

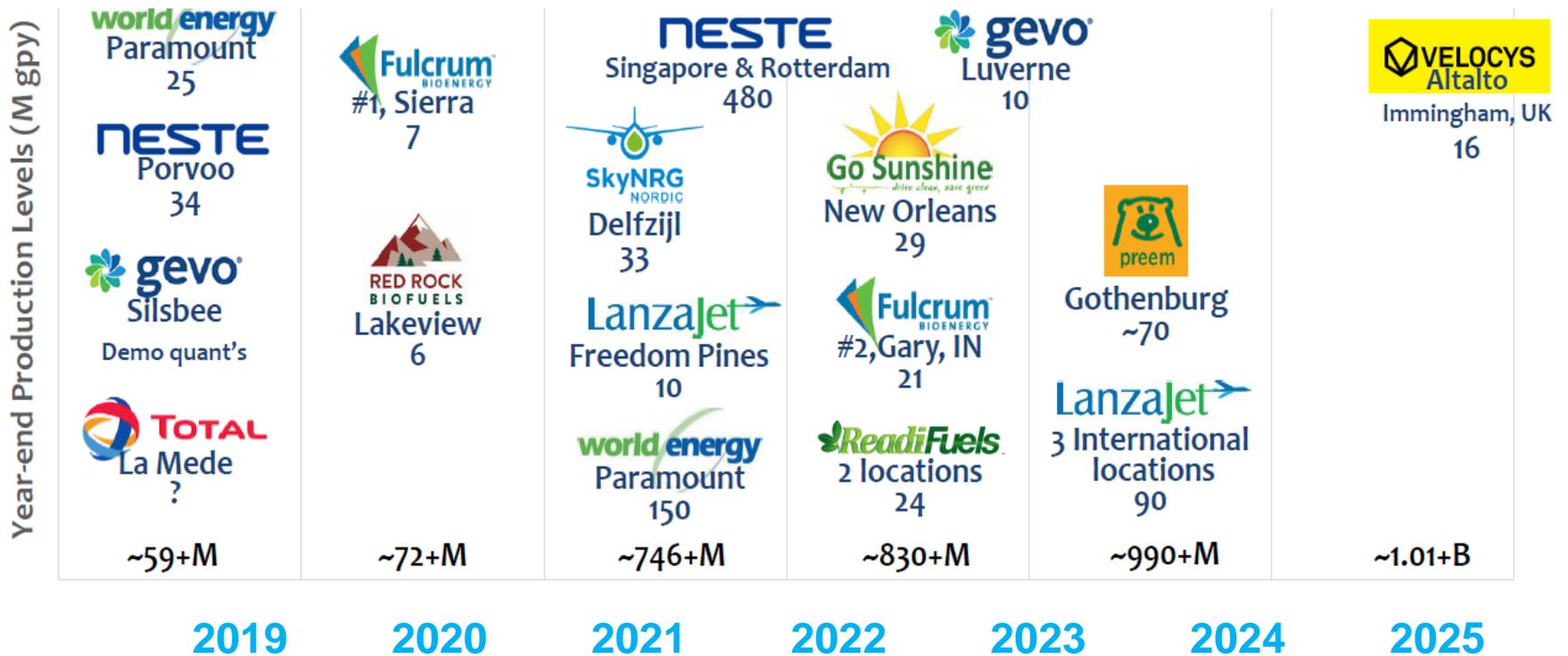
\* 100M gpy by 2024 from 4 facilities

				SAF Supply explorations
				SAF Q4'18 restart at Porvoo, ~33M gpy rate, 330M gpy with Singapore by 2022; Supply to SFO, AMS,
				Up to 1M gpy, 5 yrs+ / France & EU supply
				No detail released
				10M gpy, from 2022/2023 term/blend unspecified
				Grays Harbor, WA feasibility study, and offtake agreement, tbd

Collectively, announced airline offtake agreements total \$6.4B and >350M gpy

# Worldwide SAF production Projection

## Announced intentions with specific commitments to SAF



Credit: CAAFI. Not comprehensive; CAAFI estimates (based on technology used) where production slates are not specified



Federal Aviation Administration

# Commercial Aviation Alternative Fuels Initiative (CAAFI)

A public/private partnership of FAA, A4A, AIA & ACI-NA

- **Continued outreach & coordination**
- **2021 Goals & Priorities**
  - Communicate the Value Proposition of SAF
  - Enhance the Fuel Qualification Approach
  - Align Efforts to Enable Commercial Deployment of U.S. SAF Supply
  - Implement Frameworks & Share Best Practices
- **Virtual workshop planned for June 2021**
- **In person General Meeting for June 2022**



# Next Steps

- **Establish the development of Sustainable Aviation Fuels (SAF) as a key DOT and U.S. climate priority**
  - Continue funding of testing efforts including higher blend levels
  - Continue Analysis efforts to address scaling and deployment of fuels
  - Continue outreach via CAAFI to support industry activity
  - Exercise leadership on the Biomass Board to promote interagency support for SAF
  - Develop a multi-agency roadmap for increasing use and availability of SAF
  - Monitor legislative efforts underway for SAF support policies





# QUESTIONS

