Sustainable Aviation Fuels (SAF)

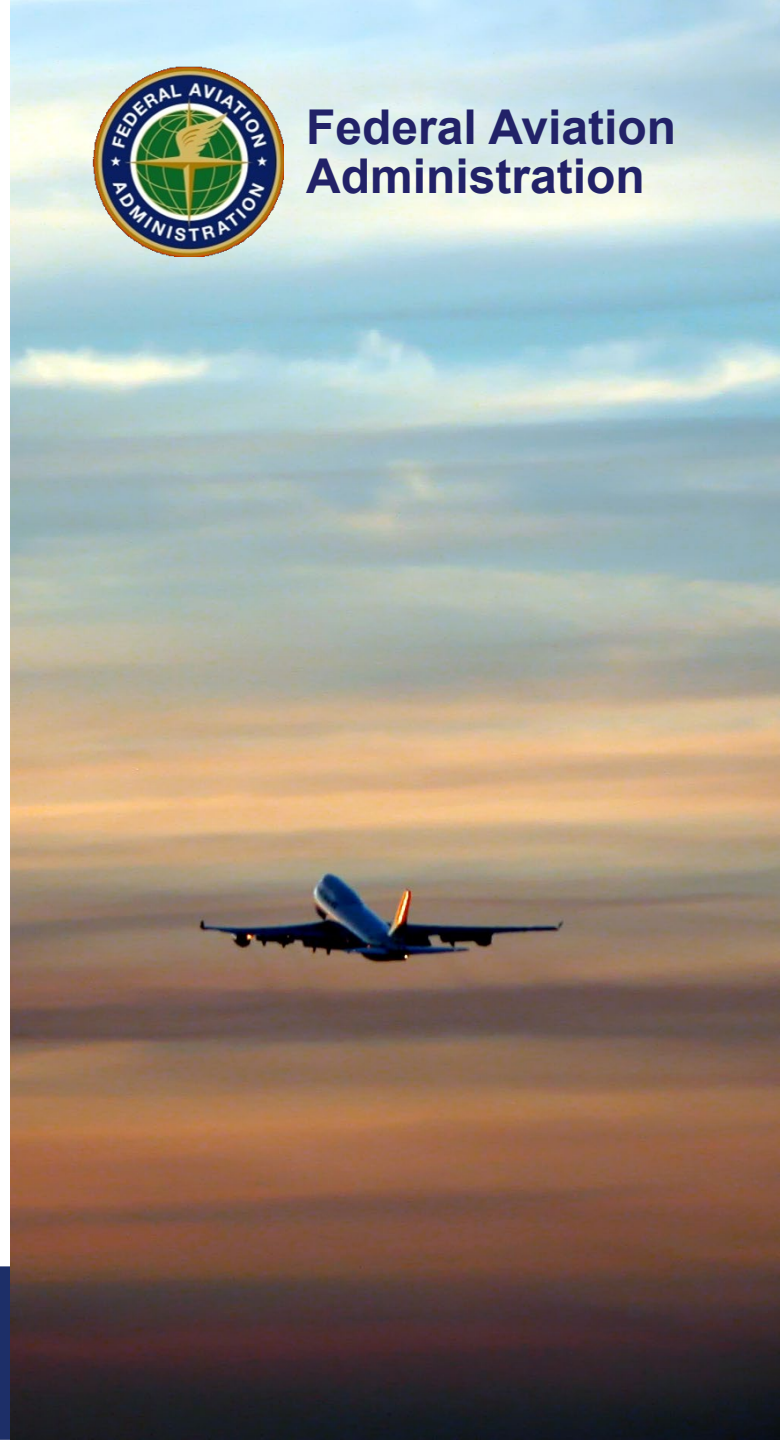
Update to FAA REDAC E&E Subcommittee

To: E&E REDAC Subcommittee

By: Nate Brown & Anna Oldani

Date: September 17, 2020

Federal Aviation Administration



FAA SAF Program Focus

Testing
accelerate SAF development

- Improve testing methods
- Conduct evaluation
- Streamline approval

Analysis
quantification of impacts

- Emissions reduction
- Supply potential
- Supply chain opportunities

Coordination
support SAF integration

- Public-private partnership – *CAAFI*
- Federal cooperation
- International cooperation – *ICAO*

Agenda

Testing

- Qualification Process
- ASTM Status

Analysis

- Supply Chain Tools & Analysis

Coordination

- ICAO CAEP FTG & LTAG
- Federal
- Commercialization

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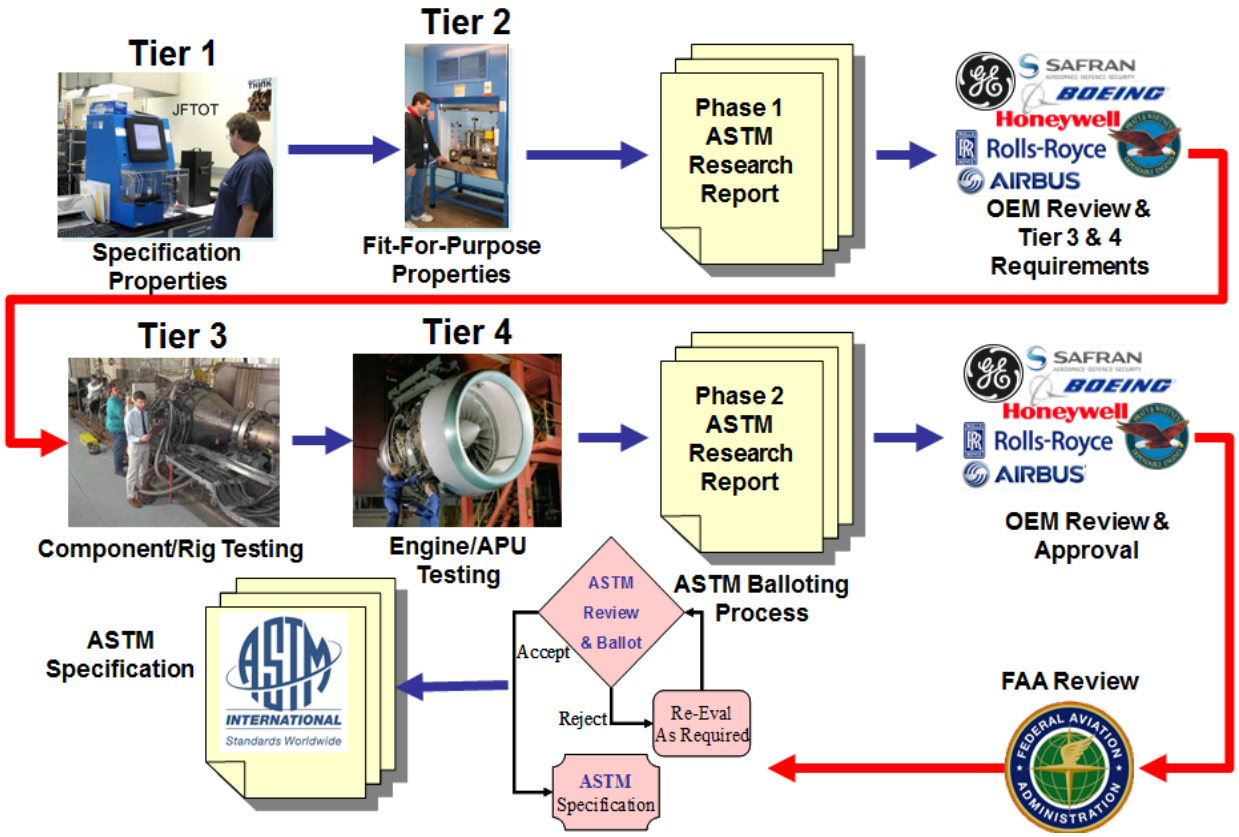
SAF Qualification – ASTM D4054

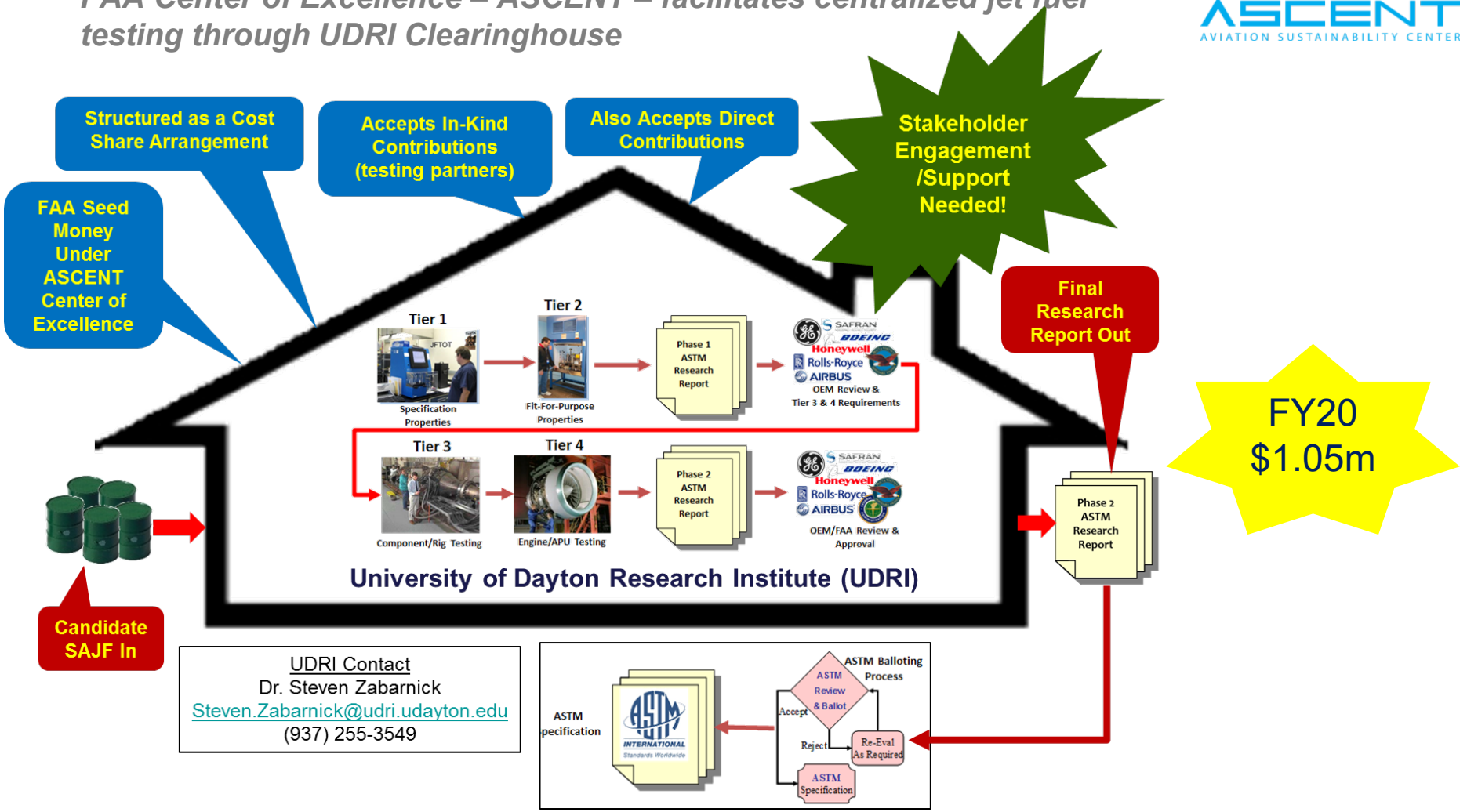
Multi-tiered qualification process involves stakeholders across industry and government



- ***ASTM International*** manages jet fuel specification
- **FAA** and **Defense** support evaluation of SAF through:
  - *Clearinghouse*: certification & qualification testing
  - Data gathering & review
  - New test method development

Clearinghouse Concept

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



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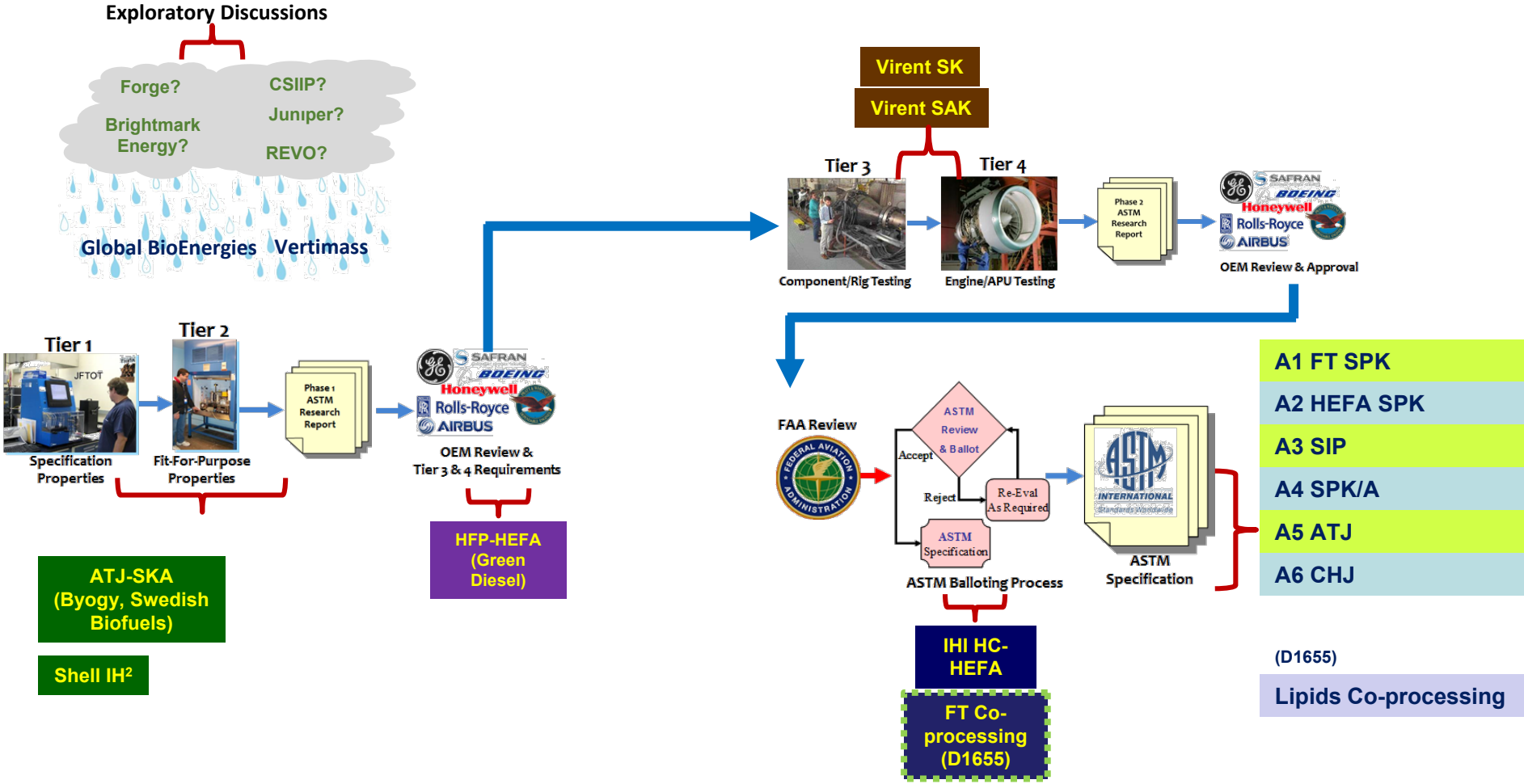
ASTM D4054 SAF Qualification Status

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



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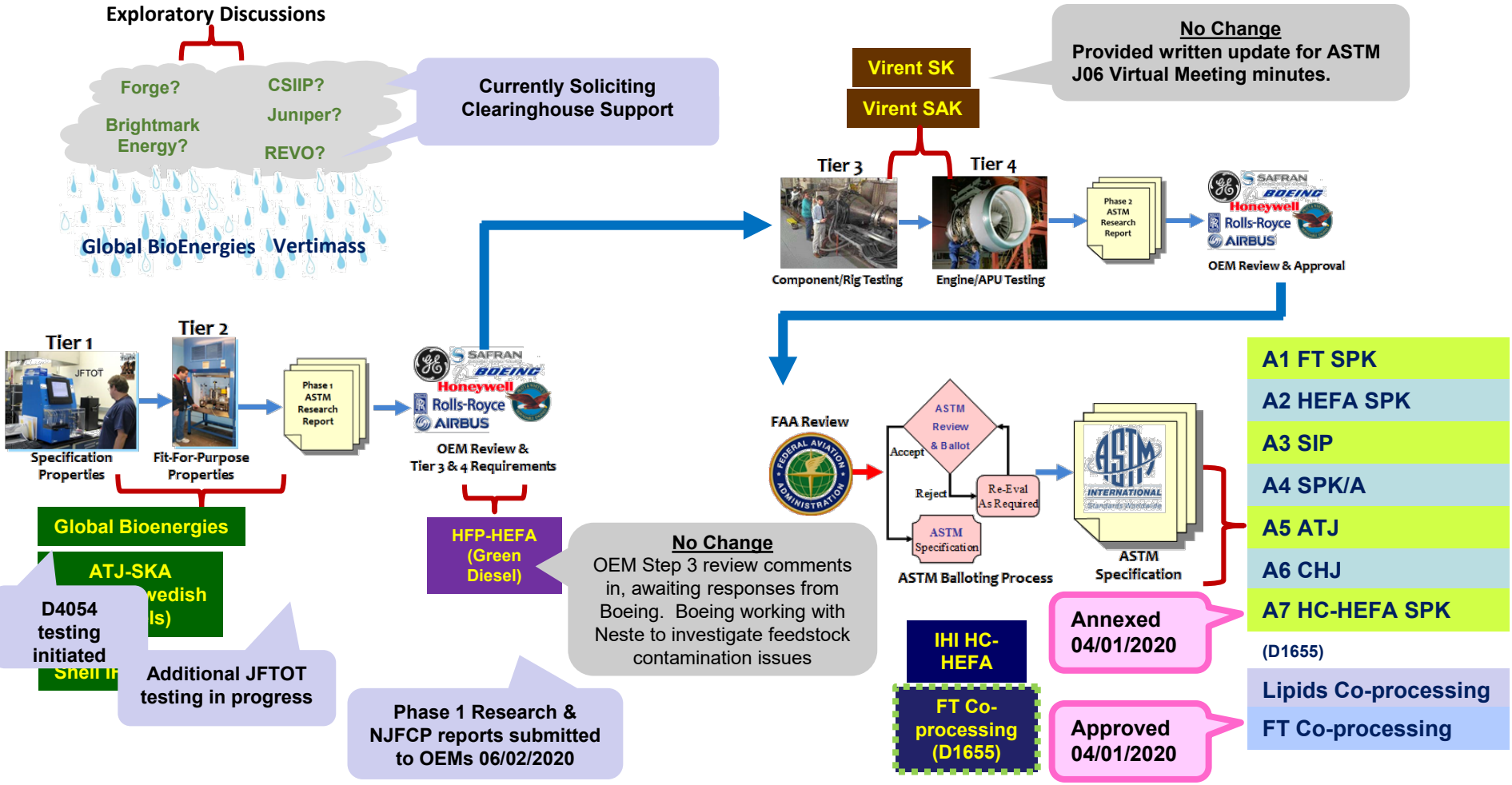


Reduce Fuel Approval Volumes

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[1]	3 years	Mostly normal/ iso-paraffins
HEFA-SPK	06/2008	05/2010	07/2011	626,000[2]	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[3]	5 $^{1}/_{2}$ years	
Lanzatech ATJ-SPK (ethanol)	09/2016	07/2017	04/2018	50[4]	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% cycloparffin

**Approved at 10% volume*

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

ARA – Applied Research Associates

[1]USAF fuel purchases in 2007-08 for fleetwide qualification

[2]USAF & Navy fuel purchases in 2009-11 for fleetwide qualification

[3]USAF, Navy and CLEEN fuel purchases in 2012-2014

[4]Only Tier 1-2 testing due to existing knowledge base and similarity to approved fuels

Fuel Composition Impacts

Evaluate added value, limiting criteria or bottlenecks for alternative jet fuels

066 High Thermal Stability Fuels

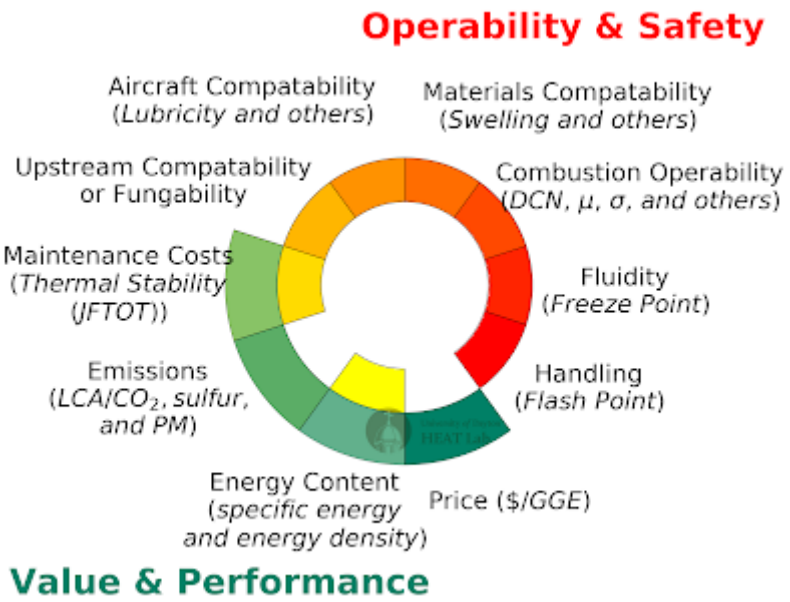
(University of Dayton, GE)

- Characterize system benefits from high thermal stability fuels - AJFs
  - Improve coolant features
  - Eliminate redundant engine components
  - → ***Reduce fuel burn and emissions***
- Evaluate impact of fuel composition on thermal stability

073 Combustor Durability

(UDRI)

- Examine effect of fuel composition on combustor life
- Quantify potential system benefits
  - Improve combustor durability
  - Reduce lifetime maintenance costs
  - → ***Determine added value of AJFs***



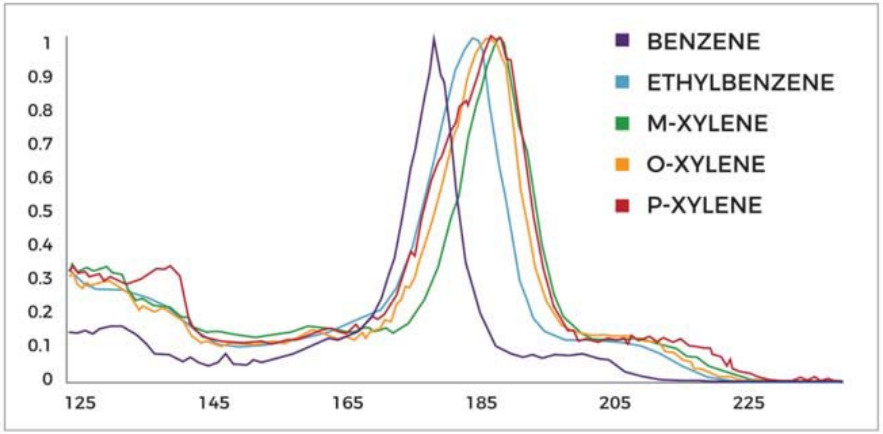
Fuel Prescreening Efforts

Facilitate minimal volume screening to support fuel producers

- Develop rapid, early stage fuel screening
- Support ***market penetration*** of US-based AJFs
- Identify and address potential ***bottlenecks and opportunities*** for AJF producers
- Develop methods to predict key properties from ***minimal fuel volumes***

025 Infrared Fuel Screening
(Stanford)

065 Rapid Testing Approaches
(University of Dayton)



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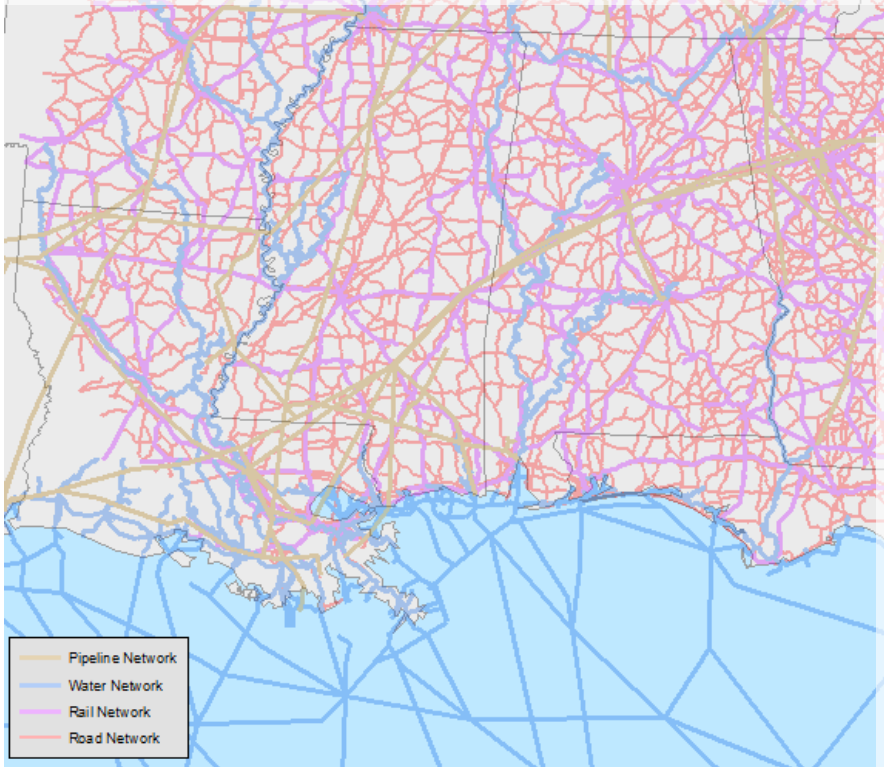
Freight & Fuels Transportation Optimization Tool (FTOT)

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 2020.2 released 06/23/20**
- https://github.com/VolpeUSDOT/FTOT-Public

A01 Supply Chain Analysis (sampling of publications)

- **Impact of co-product selection on techno-economic analyses of alternative jet fuels produced with forest harvest residuals** – Biofuel Bioproducts Biorefineries (Biofpr). (WSU)
- **Rank-Ordered Analysis of Consumer Preferences for the Attributes of a Value-Added Biofuel Co-Product** (UTenn)
- **Hydrotreatment of Pyrolysis Bio-oil: A Review** - *Fuel Processing Technology. (*WSU)
- **Pulp Mill Integration with Alcohol-to-Jet Conversion Technology** - *Fuel Processing Technology*. (WSU)
- **Cost and Profitability Analysis of a Prospective Pennycress to Sustainable Aviation Fuel Supply Chain in Southern USA** – Energies. (UTenn)
- **US biofuel production and policy: implications for land use changes in Malaysia and Indonesia** - *Biotechnology for Biofuels* (Purdue)
- **Review of biomass resources and conversion technologies for alternative jet fuel production in Hawai'i and tropical regions** - Energy & Fuels. (UH and WSU)

Full list of publications: https://ascent.aero/project/alternative-jet-fuel-supply-chain-analysis/

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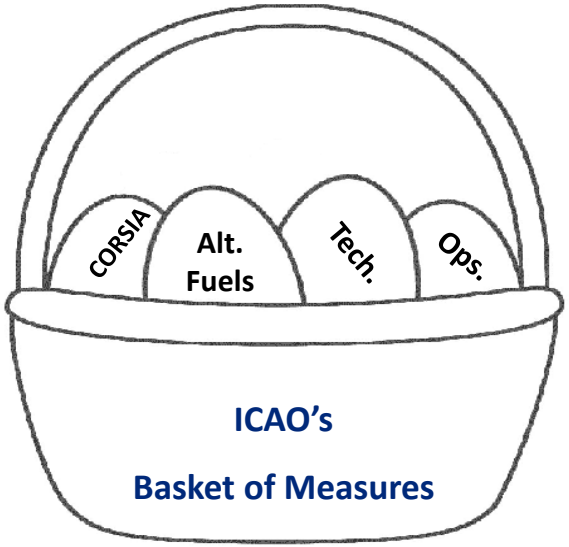
Alternative Fuels and CORSIA

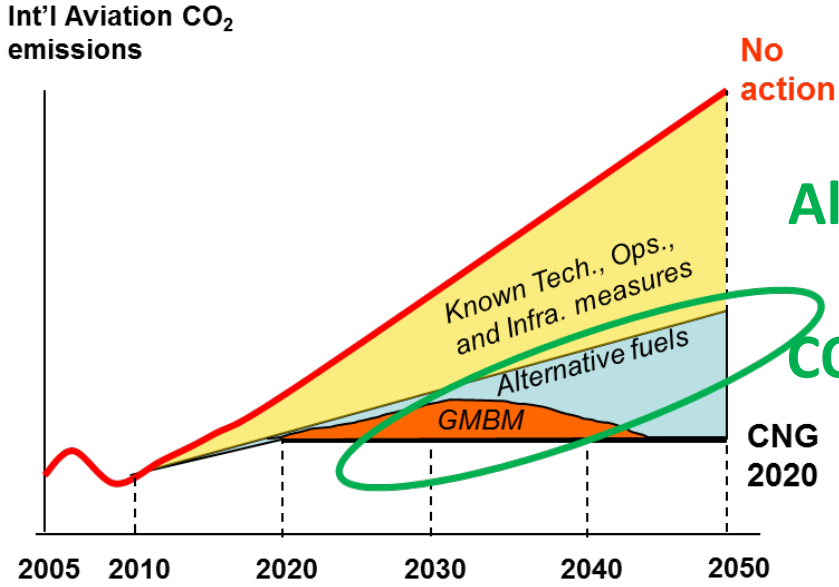
CORSIA Eligible Fuels provide a secondary means to comply with CORSIA

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





Alternative Fuels + CORSIA are Key

CORSIA
CARBON OFFSETTING AND REDUCTION SCHEME FOR INTERNATIONAL AVIATION

Update on the ICAO Fuels Task Group (FTG)

- FTG working in five subgroups.
- Held two meetings in Montreal: FTG/1 (May 2019), and FTG/2 (Sep 2019)
- Held one meeting In Abu Dhabi: FTG/3 (Feb, 2020)
- Held two meetings virtually: FTG/4 (Jun 2020), and FTG/5 (Jul 2020)
- Next virtual meeting FTG/6 (Nov 2020)

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

Ongoing Efforts in CAEP relating to SAF

CAEP Fuels Task Group (FTG)

- Maintenance of the fuels-related sections of Annex 16 Vol IV (CORSIA), including:
  - Determination of how to calculate life cycle emissions values for Lower Carbon Aviation Fuels (LCAF)
  - Calculation of default life cycle emission values for Sustainable Aviation Fuels (SAF) (including both core LCA values and ILUC values).
  - Development of proposals on strengthened sustainability criteria
- Development of guidance on potential policies for deployment of SAF

Long Term Aspirational Goal (LTAG)

- Exploring feasibility of a long-term global aspirational goal for international civil aviation CO2 emissions reductions (LTAG)
- Examining future developments in fuels, technology and operations
- Working to inform 41st ICAO Assembly in October 2022

For additional information on the CAEP Task Groups
FTG: https://www.icao.int/environmental-protection/Pages/CAEP-FTG.aspx
LTAG: https://www.icao.int/environmental-protection/Pages/LTAG.aspx

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Biomass R&D Board

- BRDB: multi-agency initiative chartered to implement Federal Bioeconomy Initiative
- July 30th unanimous vote to create:
  - The Advanced Aviation Fuels Interagency Working Group (AAF IWG) under the board
- Recognition:
  - aviation sector a key driver of economic growth and job creation
  - R&D on SAF needed to reduce cost, ensure performance and address implementation for commercial, business, and military sectors
  - Several Federal government agencies playing a central role
    - DOT-FAA's ASCENT; USDA's Regional CAPs and Biorefinery Assistance Programs; and DOE-BETO's financial assistance programs and support for technology/fuel development and biorefinery demonstration.
- AAF IWG will engage federal agencies and stakeholders and report to the Board

DOE funding announcements

- **New Bioenergy Crop Research – DOE Science – 8/7/2020**
  - 15 projects; 5 years; $68M
  - Enhance understanding of the molecular mechanisms that allow the feedstock crops to be productive and survive in stressful environments.
  - ~1/3 of projects focus on pennycress (Thlaspi arvense) & camelina (Camelina sativa) both SAF relevant
- **Bioenergy Research & Development – DOE BETO - 7/31/2020**
  - 33 projects; $97M in grants
  - Scale-up of biofuel processes; waste to energy strategies; cost reduction of algal biofuels; quantification of economic and environmental benefits of energy crops, etc.
  - ~$23M for projects with SAF focus

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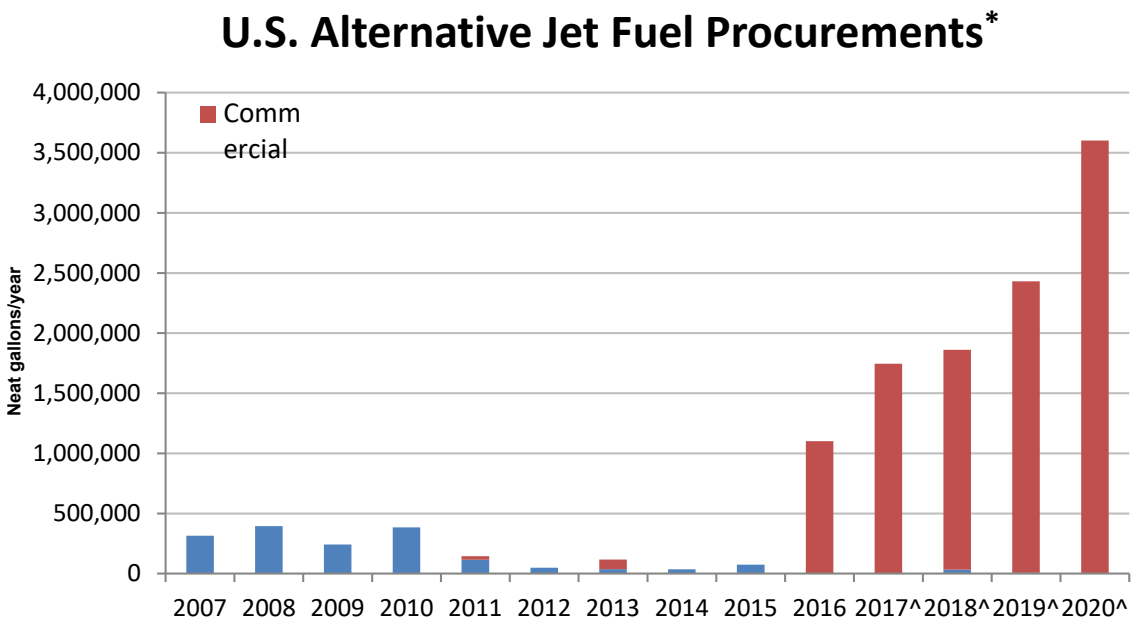
Where we stand on U.S. SAF use

Initiation under way, still early, but growing

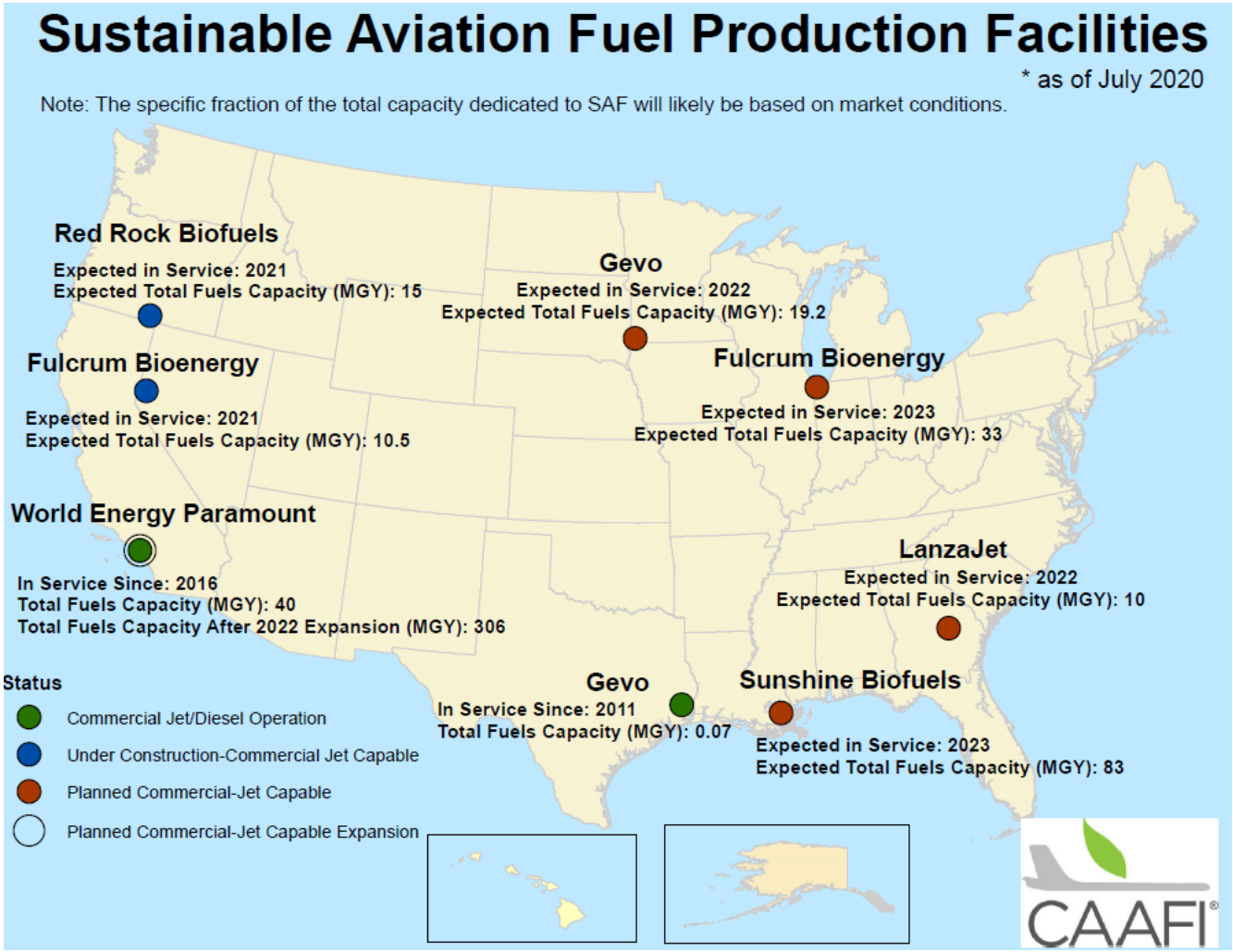
- Four years of sustained & increasing commercial use
- 3.6M gallons already in 2020!
- EPA RINs for tracking
- Commercial & General Aviation engaged
- One+ facilities in operation
- Two facilities under construction, others in development
- Cost delta still a challenge, but offtakes continue to be signed
- R&D support from federal agencies increasing



*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.

Announced SAF Production Plans in U.S.

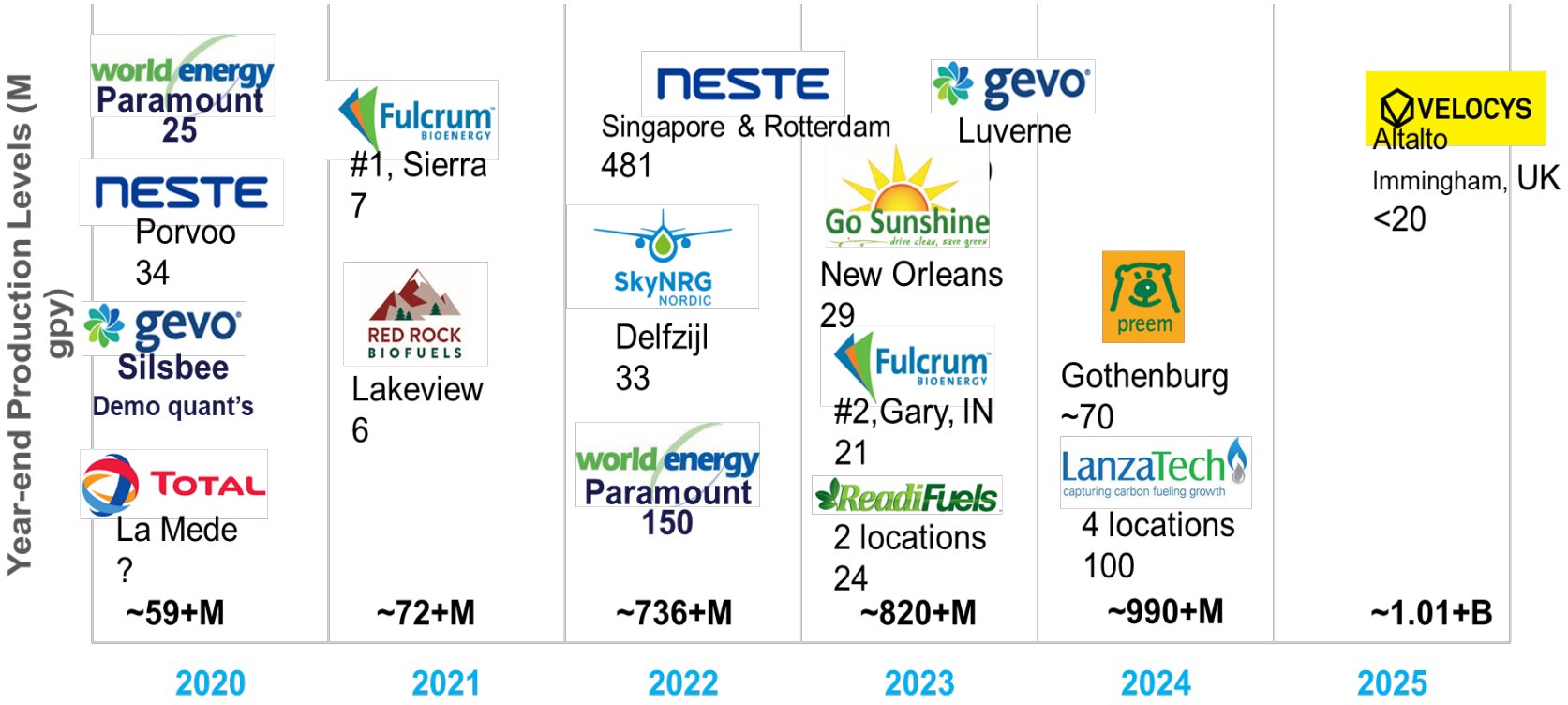
- **Six SAF producers <u>public</u>**
  - Two currently in operation
  - Two nearing construction completion
  - Four in planning
- **Total fuel capacity is diesel and SAF = ~500M gallons**
- **Available in ~3 years**
- **Others not yet public**



Credit: CAAFI®

Worldwide SAF production forecast

Announced intentions* with specific commitments to SAF

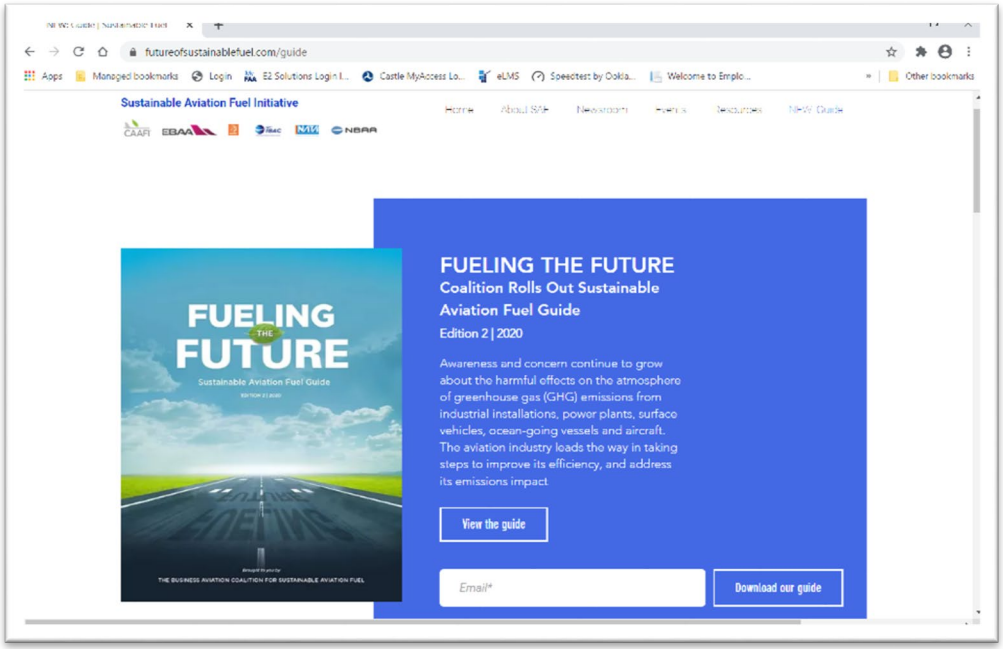


Credit: CAAFI®

* Not comprehensive; CAAFI estimates (based on technology used & public reports) where production slates are not specified

Business Aviation

- The Business Aviation Coalition for Sustainable Aviation Fuel
  - Coalition of CAAFI, EBAA, GAMA, IBAC, NATA, NBAA
    - Address knowledge gap
    - Advance proliferation of SAF
- Sustainable Aviation Fuel Guide
  - FUELING THE FUTURE
- Summit this week (Sep. 14-15, 2020)



https://www.futureofsustainablefuel.com/

Expect to see with SAF (from last REDAC)

- **Continued high level of international interest**
- **Melding of Commercial and BizAv efforts**
  - New opportunities with BizAv build on CAAFI effort
- **Concerted efforts on policy to level/advantage SAF monetize benefits**
  - RFS, LCFS, blenders tax credit, CORSIA
- **Renewed Federal agency coordination (BRDB)**
- **More aggressive airline approaches & announcements**
- **Engagement/Announcements from Big Oil**

QUESTIONS