



Federal Ministry
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology



Technology Collaboration Programme on
Advanced Motor Fuels

Webinar Series Task 63, Part 1: Supply & Operation

Some U.S. Perspectives: Sustainable Aviation Fuels



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**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.**

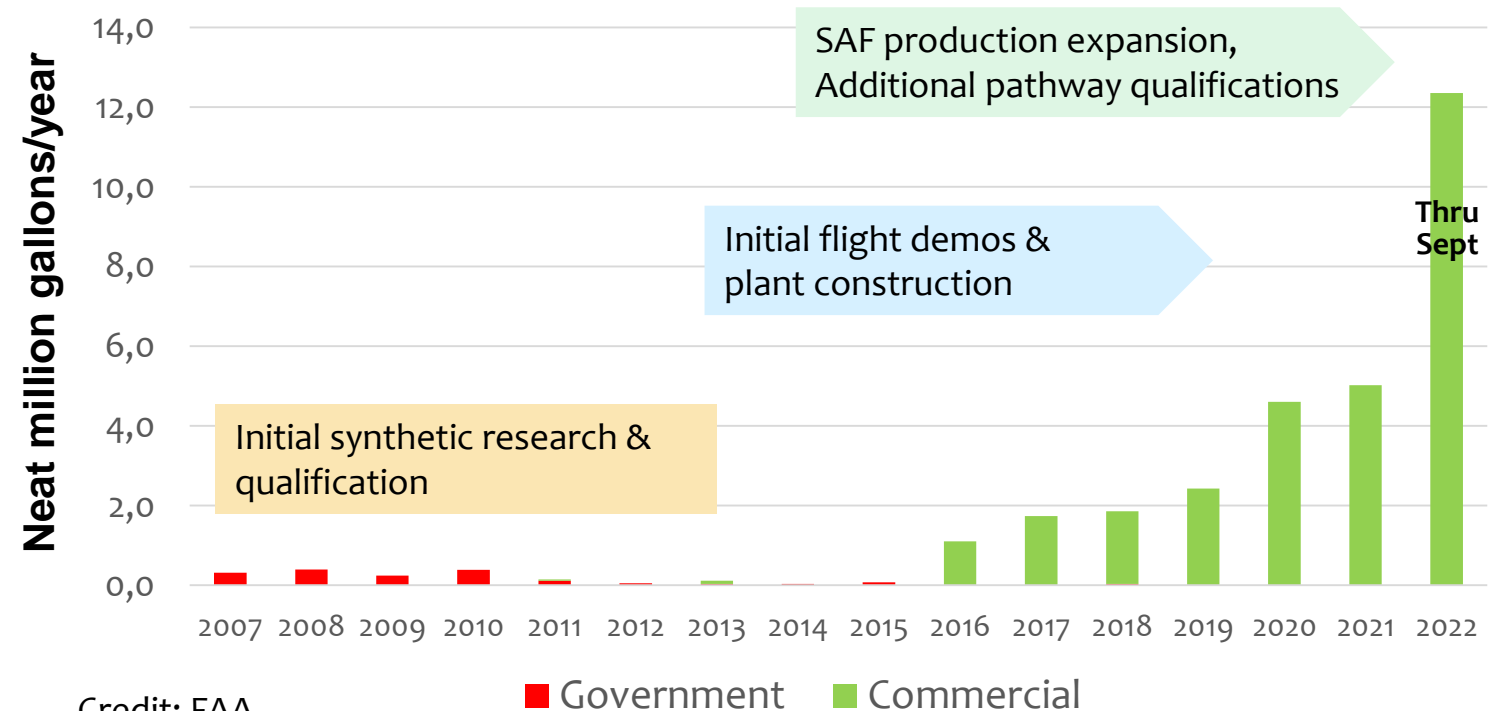
03Nov'22

Where we stand on U.S. SAF consumption

Initiation underway, still early

- * Six years of sustained commercial production and use
- * Commercial & General Aviation engaged
- * Two facilities in operation, one in commissioning, several others in physical construction
- * Cost delta still a challenge, with policies favoring renewable diesel
- * Worldwide: 6 entities produced SAF in 2021 – Finland’s Neste the market leader – some being imported to U.S. airports

U.S. SAF Procurements



Credit: FAA

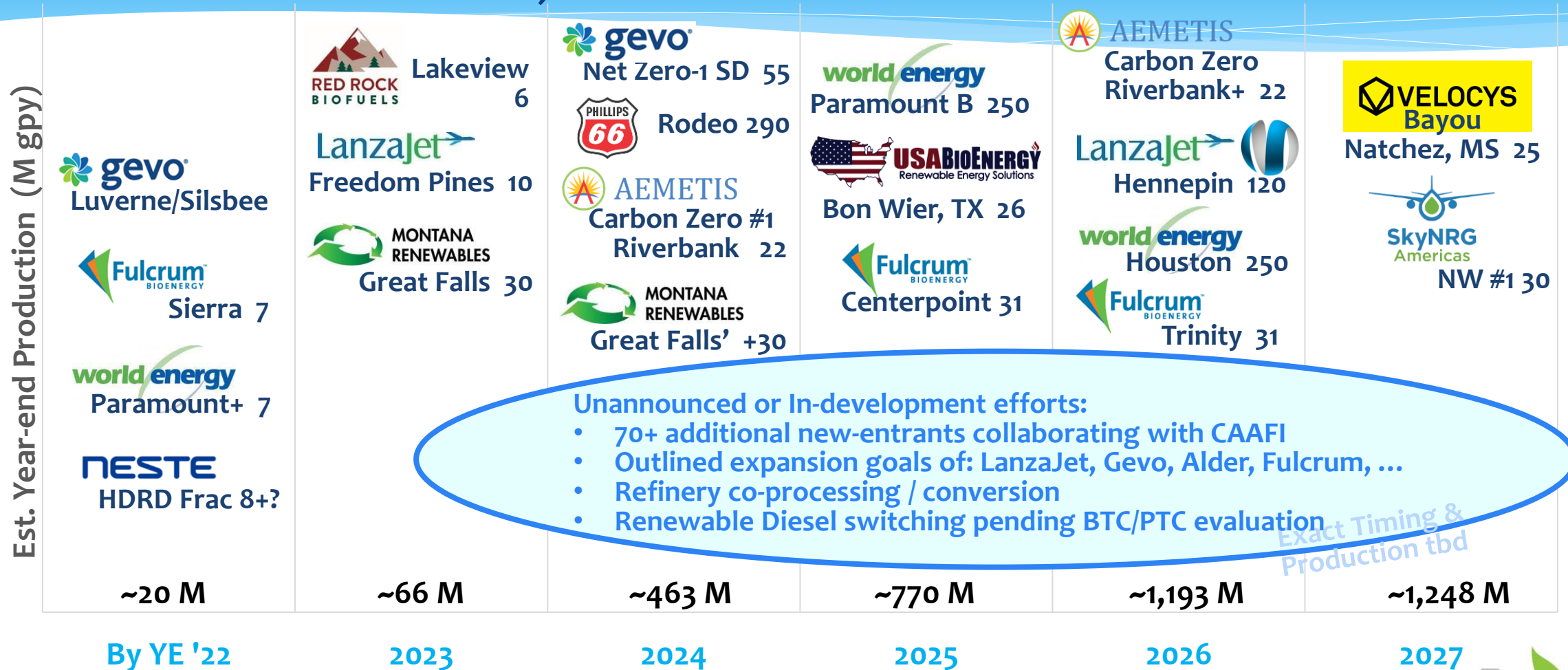
*Reflects voluntarily reported data on use by U.S. airlines, U.S. government, manufacturers, other fuel users, and foreign carriers uplifting at U.S. airports.

^2017-2021 calculation includes reported EPA RFS2 RINs for jet fuel.

2022 data as of September 2022

U.S. SAF production forecast

Announced intentions, neat*



Unannounced or In-development efforts:

- 70+ additional new-entrants collaborating with CAAFI
- Outlined expansion goals of: LanzaJet, Gevo, Alder, Fulcrum, ...
- Refinery co-processing / conversion
- Renewable Diesel switching pending BTC/PTC evaluation

Exact Timing & Production tbd

- Not comprehensive; CAAFI estimates (based on technology used & public reports) where production slates are not specified. Does not include various small batches produced for testing technology and markets.
- Does not include fractions of substantial Renewable Diesel capacity (existing and in-development) that can be shunted to SAF based on policy support

A4A airlines' individual carbon / SAF commitments

Beyond NZC by 2050, and building to 2B gpy SAF by 2030 (commitments of Mar'21)



NZC by 2040; Deal with Microsoft for SAF from SkyNRG/World Energy; SAF supply at SFO from Neste; SAF R&D investments with WSU-PNNL; Work with Carbon Direct



Allocation with Kuehne+Nagel and Deloitte ; 9 M usg SAF supply at SFO from Neste; Science based target by 2035 with SBTi; 10 M offtake from Prometheus



SAF demo work with Exolum/Avikor on Spain – Mexico flight;



Commits to be first global carbon-neutral airline; Collaboration with corporate customers (Deloitte, Takeda); targeting 10% SAF by 2030; SAF test purchase from Chevron (El Segundo)



Achieve NZC by 2040; \$2B investment target; \$100M on Yale Center for Natural Carbon Capture



NZC by 2040; 10% SAF penetration by 2030; World Energy SAF supply; offtakes with SGPreston



Collaboration with NREL on new pathways; MOUs with Marathon & P66 – focus on CA refinery retrofits



UA First U.S. Airline to Pledge to Reduce Own Emissions by 50% (vs. 2005) by 2050; 13Sep'18. \$40M SAF Investment Fund; 27Oct'19; SAF usage at LAX since 2016



30% SAF usage by global air fleet by 2035



Midterm goal, -20% from 2019 air ops by 2030. \$40M investments in SAF and carbon reductions and removals. [14Mar'21, [Leaveless \(aircanada.com\)](https://www.aircanada.com)]



No single feedstock is targeted, nor sufficient

Aviation climate targets may drive 3 million hectares of deforestation

The aviation industry's climate targets are likely to lead to a dramatic increase in demand for palm oil and soy for aviation biofuels. A new report concludes that this may result in 3.2 million hectares of tropical forest loss – an area larger than Belgium.

Published: 01.10.2019



- * Extrapolation of uniformed positions, sacrosanct beliefs and pet-peeves can lead to extraordinary positions
- * Aviation has embraced verifiable sustainability and standards, and has shunned some more controversial solutions
- * U.S. interests unlikely to dismiss fully integrated agriculture / silviculture systems that already deliver food, feed, fuel, fiber, and multiple other byproducts and remain capable of further sustainable expansion.

Promising emerging technologies / feedstocks

- * **Those that lower cost or increase value of total production slate**
 - * **Higher carbon utilization from feedstocks**
 - * **Lower CapEx and/or Lower OpEx – enabling use of low-cost, plentiful, 24x7 supply**
 - * **Integrated systems**
 - * **Finding higher value for production slip streams or byproducts**
 - * **Capturing value from other environmental services**
 - * **Driving to ultra low CI scores to increase value from rewarding policy**
- * **Steady stream of low TRL examples for the above**
- * **In some other cases, difficult to envision near-term tangible progress**

Current SAF expansion Enablers

- * **Increasing engagement from:**
 - * **Buyers: Airlines, BizAv, Scope 3 users, Suppliers, Freight**
 - * **Regulators and Policy-makers: International, US, State & Regional**
 - * **ARP, II&JA, SAF Grand Challenge, IRA,**
 - * **Third Parties:**
 - * **Recent announcement from Breakthrough Energy Collaborative and other philanthropics**
 - * **Producers: Entrepreneurs, Existing Renewables, Existing petroleum**
 - * **Feedstock providers, USDA focus**
 - * **Technology developers**
 - * **International collaboration, policy, ...**

SAF Grand Challenge (SGC)

All of gov. approach to enable: 10% neat SAF usage by 2030, 100% by 2050

- * Execution Roadmap V1.0 released on 23Sep'22
- * Execution via multiple mechanisms, likely matrixed workstreams, via 6 key foci
 - * Feedstock Innovation
 - * Conversion Technology & Processes
 - * Building Regional Supply Chains
 - * Policy and Valuation Analysis
 - * Enabling End Use
 - * Communicating Progress & Building Support
- * The expanded approach outlined by the SGC is not fully funded at present. The IRA addresses some opportunities. So, efforts will likely be needed in subsequent budgets (various DOE Offices, FAA AEE, USDA Farm Bill, ...), requiring industry advocacy.
- * Some efforts already underway – e.g. LCA Interagency Working Group

Activity has transitioned to defining work teams, leadership, operating norms, inventorying current activities and funding, ...

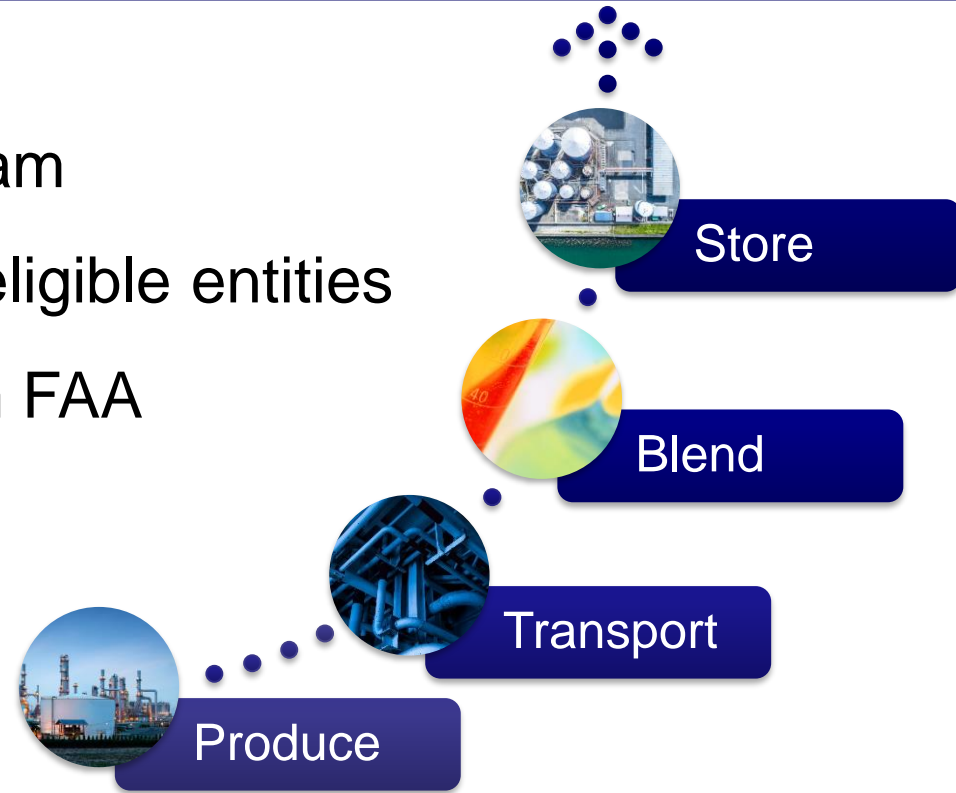
SGC execution examples

Specific applicability to SAF

1. DOE Award: [BETO Scale-Up and Conversion](#), \$64.7M over 22 projects
2. DOE FOA: [Waste Feedstock & Conversion](#), \$34.5M, LOI 18Apr'22, Full Appl. 07Jun'22
3. USDA Award: [Climate Smart Commodities](#), \$2.8B+, 70+ projects, 2 tranches, 14Sep'22
4. USDA RFA: [NIFA/AFRI SAS CAPs](#), \$80M, projects to \$10M, LOI 27Apr'22
5. DOE/SC/BER FOA: [Biosystems Design ... Biofuels](#), \$1-5M for 6-12 projects
6. RFI: [Biomass Conversion R&D and Analysis](#)
7. RFI: [Community-Scale Resource and Energy Recovery from Wastes](#)
8. RFI/NOI: [BETO Scale-Up and Conversion](#), initial FOA pending
9. DOE BERCC Renewals: 2 of 4 centers have SAF-specific thrusts
10. DOT funding in IRA (next page):

IRA grant program will support projects to rapidly scale-up domestic SAF production

- §40007
- \$245 million competitive grant program
- Specifies consideration criteria and eligible entities
- Stay tuned for more information from FAA
- RFI Imminent, RFP to quickly follow
- 4 years of funding authority



One hypothesis on delayed expansion:

Key impediment for broader commercialization is production cost

- * Physical cost is high versus petro-jet baselines
- * Higher value of adjacent products – chief being Renewable Diesel
- * Without support from high price commitments, from credit worthy customers, pro-forma business cases do not merit strong consideration without policy support, and capital markets are reticent to lend
 - * Not an issue of funding availability – rather funding appetite
- * Issue can perhaps be addressed via: additional policy support; looking at different ways to do business; continued R&DDD; ...
- * Not an issue of Operational Impediments, while other prospective issues continue to be worked (e.g. 100% SAF, co-processing, ...)

Seeding additional ideas

Technology

- **Enabling ubiquitous carbon capture (direct or stack-specific) and sequestration**
[Relationship with Carbon Removal X-Prize currently in-process]
- **Enabling low-cost green hydrogen production with focus on improved catalysis**
- **Enabling ATJ with bolt-on to existing/future alcohol facilities**
- **Enabling PTL with CO₂ from existing/future alcohol, ATJ or GFT facilities**
- ...
- **Initiating a roadmap for significant carbon-free power production at ‘every’ airport to enable future transitions of onsite production: SAF, PTL, hybridization, electrification, and hydrogen production / liquefaction**

Seeding additional ideas

Policy or ways of doing business

- National LCFS System
- Aggregation of demand from customers with less price sensitivity
- Book & Claim System: International adoption, International registry
- U.S. Federal backstopping of supply agreements from lower credit-worthy customers
- ...

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