Current State of Alternative Jet Fuel Deployment

10 July 2019
Sustainable Aviation Fuel Production

- Three years of sustained commercial production and airline use
- >1.2 million gallons in 2018 from additional producers, users, and airports
- New fuels under evaluation & construction of new facilities under way
- Potential for 250+ million gallons/year in <five years

U.S. Sustainable Aviation Fuel Procurements*

* Reflects voluntarily reported use by U.S. airlines, U.S. government, manufacturers, other fuel users, and foreign carriers uplifting at U.S. airports.
Sustainable Aviation Fuel Production Facilities

Note: The specific fraction of the total capacity dedicated to SAF will likely be based on market conditions.

Red Rock Biofuels
Expected in Service: 2020
Expected Total Fuels Capacity (MGY): 15

Fulcrum Bioenergy
Expected in Service: 2020
Expected Total Fuels Capacity (MGY): 10.5

World Energy Paramount
In Service Since: 2016
Total Fuels Capacity (MGY): 40
Expected Total Fuels Capacity After Expansion (MGY): 306

Fulcrum Bioenergy
Expected in Service: 2021
Expected Total Fuels Capacity (MGY): 33

SG Preston
Expected in Service: 2021
Expected Total Fuels Capacity (MGY): 240

LanzaTech
Expected in Service: 2019
Expected Total Fuels Capacity (MGY): 10

Gevo
In Service Since: 2011
Total Fuels Capacity (MGY): 0.07

Status
• Commercial Jet/Diesel Operation
• Under Construction-Commercial Jet Capable
• Planned Commercial-Jet Capable
• Planned Commercial-Jet Capable Expansion

* as of June 2019
SAF and Renewable Diesel Production Facilities

Note: Some fraction of renewable diesel could be converted to SAF production and/or the aviation industry is evaluating the use of renewable diesel as a blending component for jet fuel.

* as of June 2019

Map showing facilities across the United States with different markers indicating status.

Status:
- Commercial Jet/Diesel Operation
- Commercial Renewable Diesel
- Planned Commercial-Jet Capable Expansion
- Under Construction-Commercial Jet Capable
- Planned Commercial-Jet Capable
- Initial Exploration-Commercial Jet Capable
Current SAF Commercial Production & Offtake Agreements

- Began commercial production in 2016 supplying LAX
- Over 1 Million gallons per year of SAF since 2016
- Moving forward with $350M expansion to enable 306M gpy total capacity, including infrastructure for jet capacity of 150M gpy; 24Oct’18

neat quantities

Up to 5M gpy from 2016 (LAX) (renewed up to additional 10M for 2019-2020)

3 yr agreement
30/70 blend

3 yr agreement
Enabling LAX flts

Bioports on demand, et al.

* WEP also continues supplying fuel for multiple trial and research activities

An offtake agreement is an arrangement between a fuel buyer and fuel producer to purchase a portion of the fuel producer’s future production.
United is the only U.S. airline flying on SAF on a continuous basis

United began flying World Energy’s SAF from its Los Angeles hub in March 2016.

United has bought 3 million gallons of SAF from World Energy, more than any other airline in the world.

The SAF is made from tallow, an inedible substance made from beef fat.

Through the end of 2018, United has flown the equivalent of over 2,700 SAF flights.

World Energy’s SAF provides a greater than 60% reduction in CO₂ emissions on a lifecycle basis when compared to traditional jet fuel.

This project created 65 new jobs at the previously idle refinery in Paramount, California.
Obtain 30% of jet fuel from alternative sources by 2030; 06Nov’17
In 2015 United invested $30 million in Fulcrum BioEnergy to convert municipal solid waste (MSW) into SAF

- Capture recyclables, generate renewable electricity credits, and produce fuel
- Greater than 80% reduction in CO₂ lifecycle emissions
- Co-develop up to five facilities (first SAF facility: Gary, Indiana)
- 900 million gallons over 10 years
Q: What about the price premium?
A: Airlines aren’t willing to pay a premium

- Avoided costly startup expenses, so reduced need for cost recovery or to advance down the learning curve
- Cost/risk-sharing agreement

- Using MSW as feedstock at no cost; some studies show that feedstock is as much as 80% of the cost
- Bringing in investors from across the value chain who receive different benefit streams
U.S. SAF Offtake Agreements

- **gevo** + **Avfuel** = Up to 1M gpy, 5 yrs+
- **Virgin Australia** + **Qantas** = Brisbane Supply Demonstration
- **SG Preston** + **JetBlue** = 10M gpy, 10 yrs (JFK)
- **Velocys** + **British Airways** + **Shell** = MSW-based FT-SPK evaluations
  - In negotiation
  - BTL #1, Natchez, MS 1,400 bpd
International SAF Offtake Agreements

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- AGRISoma + QANTAS = Carinata supply development
- SkyNRG + KLM = 24.6M gpy, 10 yrs
- TBA + FINNAIR = A350 deliveries 10% blend (ex-TLS)
- Total | AMYRIS + CHINA AIRLINES = Customer funding of SAF purchase from 2019
U.S. SAF Exploratory Agreements

- SAF Supply exploration
- MOU to design & implement adoption
- Collaboration on supply expansion

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Other recent announcements

DG Energy + GE Aviation + World Fuel Services + SAS

Multiple Producers, TBA + Gothenburg Refinery + LanzaTech + virgin atlantic

Multiple Producers & Suppliers + Airports and Airline Tenants

Full production slate offtakes
Long-term supply negotiation (from 2023). Fueling all domestic flights by 2030.
UK DfT F4C Funding: ATJ Development Demo flight MCO-LGW

Exploration of Greater ambition
For more information regarding the current state of alternative jet fuel development visit caaфи.org