Working Document of the NPC Study
Dynamic Delivery –
America's Evolving Oil and Natural Gas Transportation Infrastructure
Made Available December 12, 2019

Topic Paper #1-1

BIOJET

Prepared for the
Supply and Demand Task Group

On December 12, 2019, the National Petroleum Council (NPC) in approving its report, *Dynamic Delivery – America's Evolving Oil and Natural Gas Transportation Infrastructure*, also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the study's Supply and Demand Task Group. These Topic Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents, but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached paper is one of 26 such working documents used in the study analyses. Appendix C of the final NPC report provides a complete list of the 26 Topic Papers. The full papers can be viewed and downloaded from the report section of the NPC website (www.npc.org).

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Topic Paper

(Prepared for the National Petroleum Council Study on Oil and Natural Gas Transportation Infrastructure)

1-1	**Biojet**
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Reviewers	
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SUMMARY

This paper discusses the various pathways to produce Sustainable Aviation Fuel (SAF), fuel made from renewable, non-fossil-derived raw materials, which once blended with petroleum jet fuel is suitable for use in an unmodified jet engine. Current and future production levels, as well as some of the regulatory initiatives to promote demand are also described.

The modern phrase for "biojet" is Sustainable Aviation Fuel (SAF) and refers to fuel made from renewable, non-fossil raw materials that once blended with petroleum jet fuel is suitable for use in an unmodified jet engine. Currently five production pathways are approved by ASTM for use, blended at varying percentages up to 50% (Figure 1). These 5 alternative pathways, alongside "traditional" petroleum jet production, all qualify for the ASTM standards for jet fuel.

Production of SAF has been low considering the five available pathways due to the high cost versus fossil fuel. The leading stakeholder coalition in the U.S. is the Commercial Aviation Alternative Fuels Initiative (CAAFI), which projects potential global production of 250 million, or more gallons per year in less than 5 years, based on announced facility construction or expansion plans.

The cost of producing SAF is estimated by one U.S. airline to be 2 to 3 times the cost of fossil-fuel based jet fuel, although this cost is lower than the company's initial use of SAF that cost six times more than fossil jet fuel.[1] Additionally, past and current economic incentives can steer processing of renewable feedstocks toward other products. Like biodiesel or renewable diesel, SAF qualifies for a Renewable Identification Number, or RIN, credit; however, producers have focused on more lucrative diesel economics for the past decade. Biodiesel was incentivized by a considerable $1/gallon tax credit through 2017, and renewal of the incentive is proposed for 2019.

[1] International Air Transport Association, "The Cost of Going Green," May 24, 2017, https://airlines.iata.org/analysis/the-cost-of-going-green.

Despite the high cost, there is worldwide interest in SAF– governments are seeking to diversify jet supply from the traditional hydrocarbon molecule, particularly when oil prices rise. Greenhouse gases also remain a concern for the aviation sector in general. The United Nations' International Civil Aviation Organization, Carbon Offsetting and Reduction Scheme for International Aviation has mandated that airlines achieve carbon neutral growth starting in 2020 in the international air space, and airlines have agreed to cut net CO_2 emissions 50% by 2050 versus 2005 levels. There are currently two ways to be carbon compliant: utilize a low-carbon fuel such as SAF or participate in market-based emission offset schemes such as emissions trading.

As of end-2018, there exist five approved "types" of SAF[2], none of which contain more than 50% renewable fuel (Table 1). This blend must pass the ASTM D 7566 quality test for renewable jet fuels. Once passed, it qualifies as a "D 1655" fuel, which is what U.S. airlines currently buy. Once this certification is achieved there is no distinction between a renewable jet fuel and a standard hydrocarbon jet fuel, which is important for the ability to "drop in" to the current jet fuel supply chain.

Demand forecasts for SAF vary widely. For this study, the U.S jet demand forecast from the Energy Information Administration 2019 Annual Energy Outlook was utilized for an overall consumption value. Of this demand, Figure 1 projects a bearish estimate of 2% biojet used for blending. Bullish forecasts from the National Renewable Energy Laboratory estimate 30% SAF usage by 2030 (Figure 2). The Aviation Benefits Beyond Borders group takes a significantly more bearish view and sees SAF consumption at 2% by 2025.

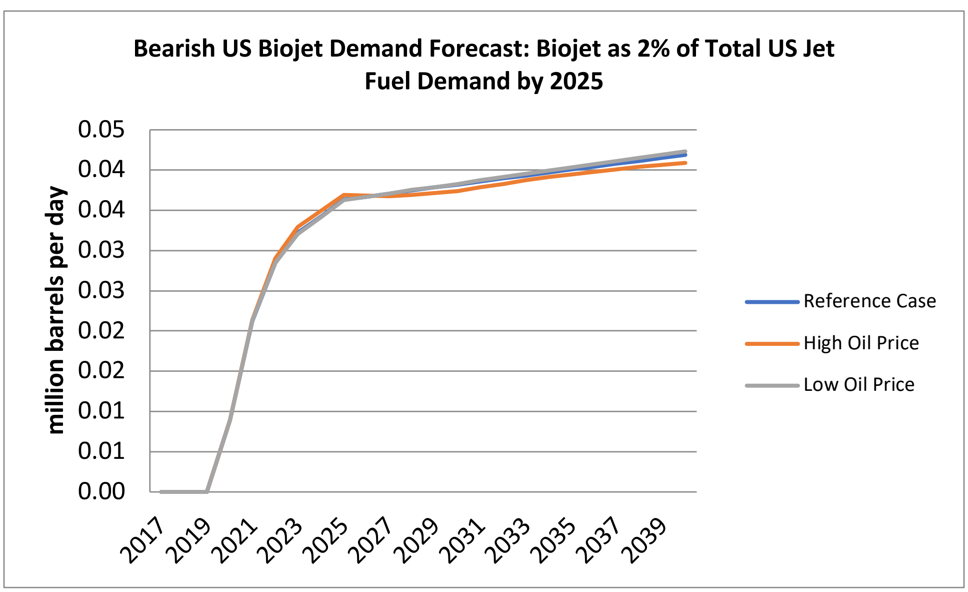

Figure 1. Bearish Biojet Forecasts

Source: Energy Information Administration 2019 Annual Energy Outlook.

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[2] CAAFI D4054 Fuel Approval Process, http://www.caafi.org/focus_areas/fuel_qualification.html

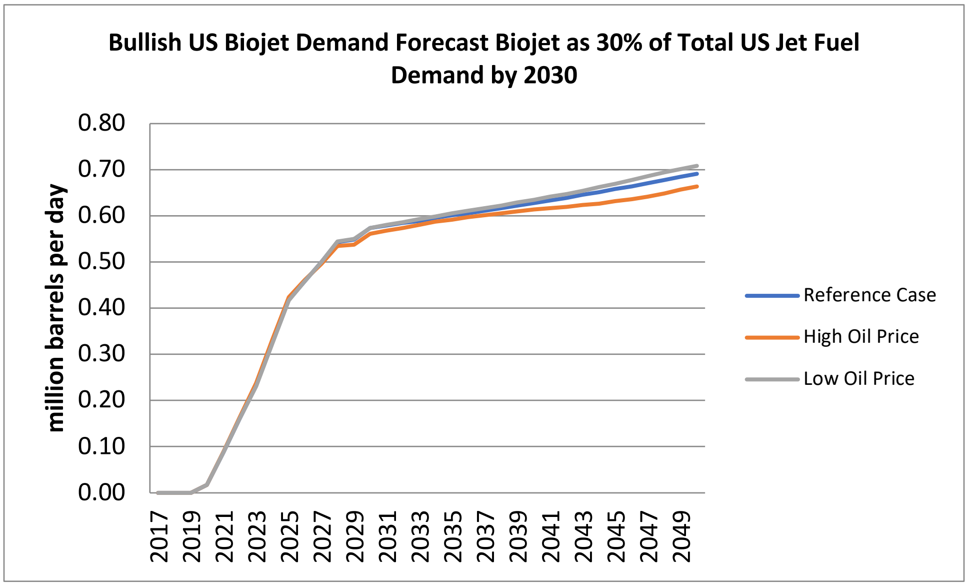

Figure 2. Bullish U.S. Biojet Demand Forecast Biojet as 30% of Total U.S. Jet Fuel Demand by 2030

Source: Energy Information Administration 2019 Annual Energy Outlook.

Table 1. Five Approved "Types" of Sustainable Aviation Jet Fuel

Drop-in alternative fuel Process	Abbreviation	Max Blend Level	Feedstocks	Year Certified
Fischer-Tropsch Synthetic Paraffinic Kerosene	FT-SPK	50%	Biomass, non-renewable feedstocks such as coal and natural gas	2009
Hydroprocessed Esters and Fatty Acids Synthetic Paraffinic Kerosene	HEFA-SPK	50%	Plant and animal fats, oils and greases	2011
Hydroprocessed Fermented Sugars to Synthetic Isoparaffins	HFS-SIP	10%	Sugars	2014
Fischer-Tropsch Synthetic Paraffinic Kerosene with Aromatics	FT-SPK/A	50%	Biomass, non-renewable feedstocks such as coal and natural gas	2015
Alcohol to Jet Synthetic Paraffinic Kerosene	ATJ-SPK	50%	Certain alcohols (ethanol and isobutanol) produced from various sources like sugars or waste hydrocarbons	2016

Currently, there is only one U.S. refinery that is consistently producing sustainable alternative jet fuel – the World Energy Paramount facility in California. In addition, SAF produced by Gevo was used at O'Hare Airport during 2017 Fly Green Day. Gevo is still producing SAF on a batch basis and will continue to do so in partnership with AvFuel, an aviation fuel supplier. Two other facilities (Red Rock Biofuels and Fulcrum BioEnergy) have broken ground on new facilities to produce SAF and expect to be in production in 2020 (Figure 3).

In addition, many existing biodiesel refineries can theoretically swing their slate to produce SAF (Figure 4), but as discussed earlier, economics are generally more favorable towards diesel than jet.

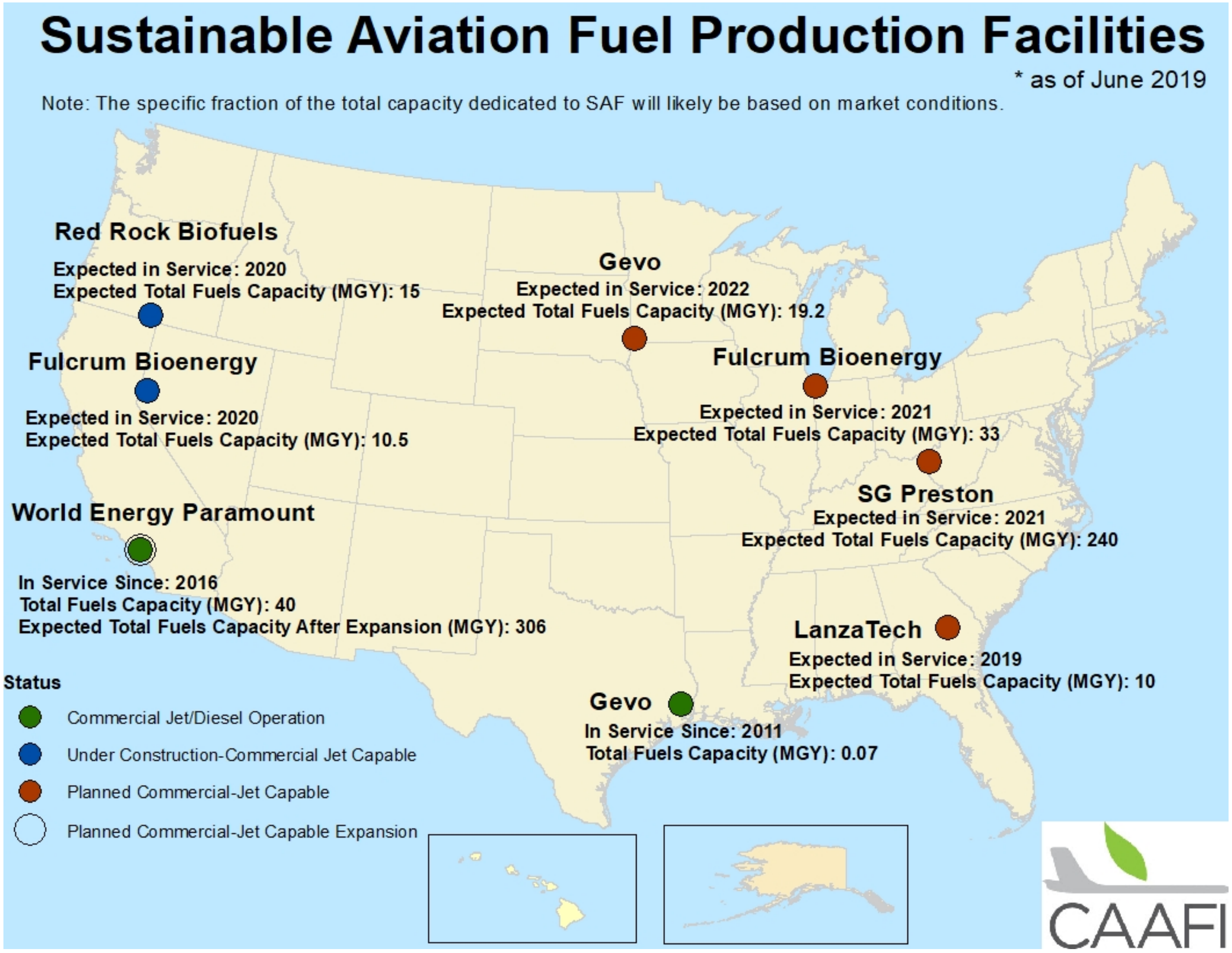

Figure 3. SAF Production Facilities

Source: Commercial Aviation Alternative Fuels Initiative

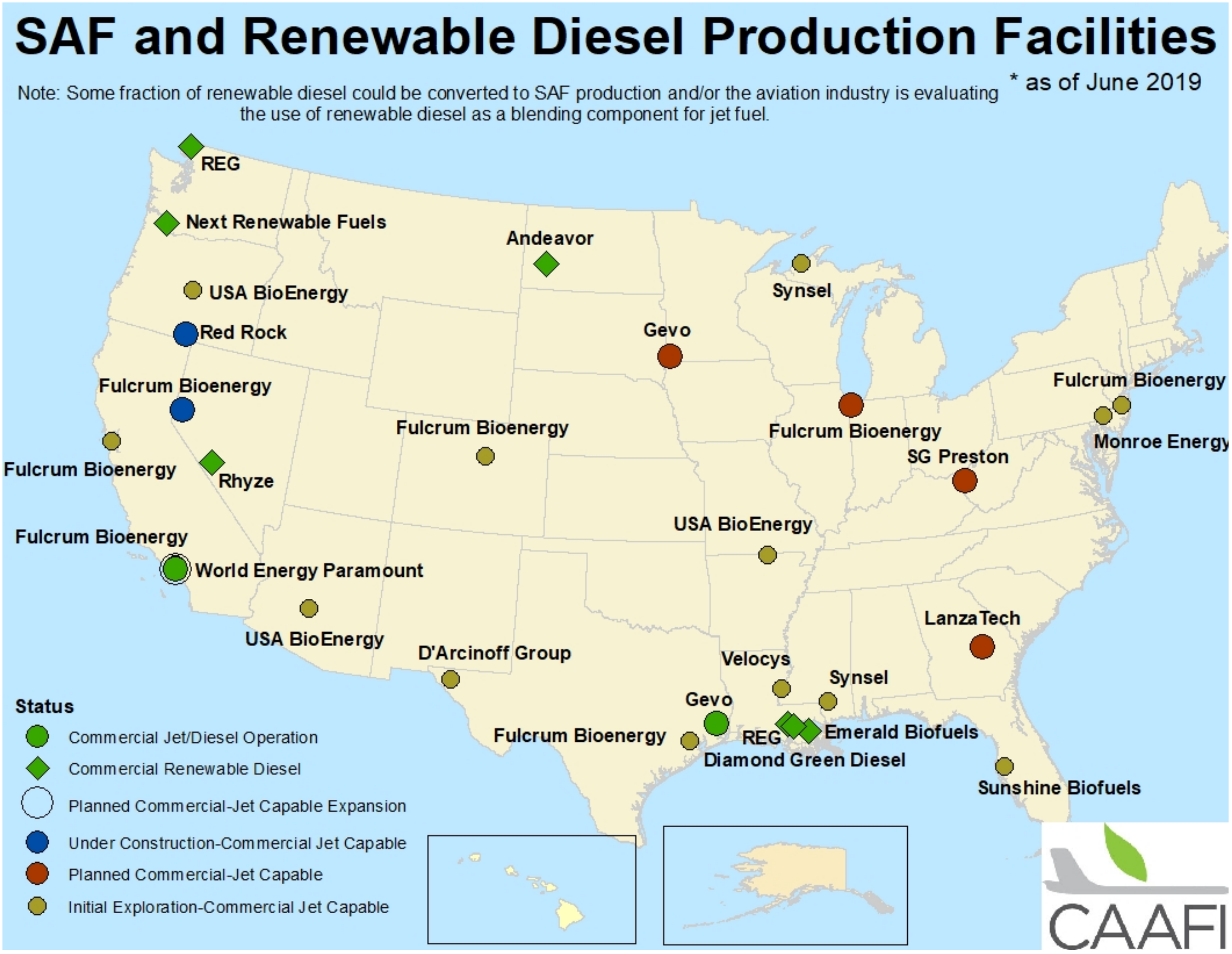

Figure 4. SAF and Renewable Diesel Production Facilities

Source: Commercial Aviation Alternative Fuels Initiative