SYSTEMS ANALYSIS AND NEGOTIATION OF STRATEGIC PARTNERSHIPS IN THE SUPPLY OF BIOFUELS TO COMMERCIAL AVIATION

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Systems Analysis and Negotiation of Strategic Partnerships in the Supply of Biofuels to Commercial Aviation

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Abstract—**Industrial supplies of energy and fuels need coordinated efforts of stakeholders to address complex challenges related to resources, finances, infrastructure, regulations, innovations, behaviors, etc. Advanced aviation biofuels, in particular, involve negotiations and tradeoffs among subsystem owners and operators, regulators, government agencies, and transportation providers. This paper utilizes a case study on biofuel distribution to Dulles International Airport to address three primary components of a systems engineering-based supply chain analysis: (i) stakeholder mapping, (ii) scenario evaluations, and (iii) resilience analysis. This paper builds upon the power-interest matrix to develop an Engagement, Financing, and Time Horizon Analysis (EFHA) matrix to support systems engineering and stakeholder negotiations for energy and fuel supply chains. EFHA identifies several key problem dimensions: coordination among diverse stakeholders, resource allocation and policy considerations, and time horizons for action. In evaluating various supply chain scenarios, the Freight and Fuel Transportation Optimization Tool (FTOT) from the U.S. Department of Transportation was utilized to assess network infrastructure, sensitivity constraints regarding feedstock and pricing assumptions, and capacity impacts of different transportation options, all in the scope of biofuel distribution. In evaluating enterprise resilience, the paper employs comprehensive systems criteria, system components, and emergent conditions to understand disruptions and scenarios that most matter to a biofuel supply chain at airports.**

I. Introduction

The increasing urgency to develop alternative aviation fuel supply chains that efficiently utilize resources from the surrounding region in the aviation sector has led to the emergence of regulatory frameworks and international initiatives aimed at fostering sustainability. The International Civil Aviation Organization (ICAO) has introduced the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), a global initiative designed to cap net CO_2 emissions from international flights at 85% of 2019 levels [1]. Through CORSIA, airlines must offset any emissions growth beyond this threshold while also pursuing additional mitigation strategies, including technological advancements, infrastructure improvements, and the integration of advanced aviation biofuels. Initially voluntary from 2020 to 2026, CORSIA will become mandatory for all international flights originating from or arriving at ICAO member states from 2027 onward, with a few exceptions [1], [2]. As a major hub for both domestic and international air travel, Washington Dulles International Airport must proactively explore strategies to facilitate airline compliance with CORSIA. A critical component of this transition is the adoption and efficient distribution of biofuels, which presents logistical, economic, and regulatory challenges that necessitate a systems engineering-based approach.

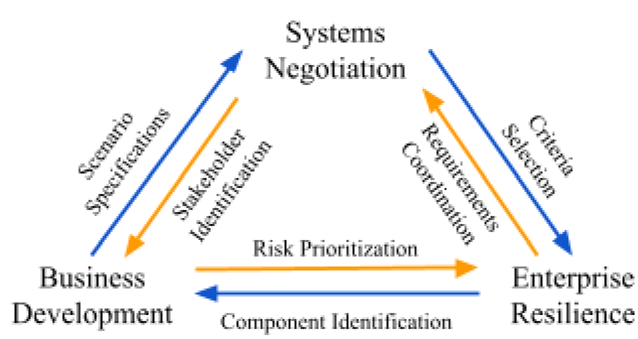

Fig. 1. Systems engineering that focuses on requirements analysis for the supply of advanced biofuels at an international airport.

This paper aims to analyze the complexities of energy and fuel supply chains with a particular focus on the integration of advanced biofuels at the airport. Given the advantageous position of Virginia with abundant feedstock resources, such as municipal solid waste (MSW), used tires, and woody biomass, the state has significant potential for biofuel production and distribution [3]. However, ensuring a seamless and economically viable supply chain for the fuels requires careful coordination among stakeholders, investment in infrastructure, and a strategic assessment of supply chain risks [4]. To address these challenges, this paper introduces a structured framework for evaluating biofuel supply chain development and implementation. Specifically, it applies a case study approach to analyze biofuel distribution to the airport through a three-pronged methodology: (i) stakeholder negotiation mapping, (ii) supply chain scenario evaluations, and (iii) resilience analysis with system disruptions. Fig. 1 depicts a conceptual framework of the interdependencies of this approach.

The remainder of this paper is structured as follows: first, background on biofuel development and regulatory frameworks is provided; next, the technical approach is detailed, including an analysis of stakeholder mapping, supply chain logistics, and system order disruptions; discussion and key findings are evaluated based on the implications for policy and stakeholder decisions; and finally, recommendations for future work are delineated.

II. Background

Aviation biofuels are a drop-in, renewable alternative to conventional jet fuel, capable of reducing life cycle greenhouse gas (GHG) emissions by at least 50% compared to petroleum-based Jet A [1]. Biofuels can be produced through various conversion pathways, including Hydroprocessed Esters and Fatty Acids (HEFA), Fischer-Tropsch synthesis, and Alcohol-to-Jet (ATJ), using feedstocks such as municipal solid waste (MSW), used cooking oil, and woody biomass [2], [5], [6]. Current American Society for Testing and Materials standards, such as ASTM D7566, limit aviation biofuels to a 50% blend with conventional jet fuel [7].

The biofuel supply chain includes six key components: feedstock sources, processing hubs, refining facilities, transportation infrastructure, blending terminals, and airport delivery systems [8], [9], [10]. These components form a complex, interdependent network that must be carefully coordinated at the regional level to ensure economic feasibility and emissions reductions. Geographic variability in feedstock type, transportation logistics, and processing capacity further complicates designing and implementing a scalable supply chain [4], [8].

Governments and regulatory bodies have introduced significant policy drivers to accelerate aviation biofuel deployment. The United States launched the Sustainable Aviation Fuel (SAF) Grand Challenge, aiming to produce three billion gallons of aviation biofuel annually by 2030 and 35 billion gallons by 2050 [5], [11]. Achieving these targets will require the development of over 400 new biorefineries and major investments in supporting infrastructure [11]. In parallel, the European Union (EU) has enacted binding mandates under the ReFuelEU Aviation Regulation, requiring biofuel blends of 2% by 2025, increasing incrementally to 70% by 2050 [12]. These mandates apply to all flights departing from EU airports, including international carriers, placing additional pressure on global aviation hubs to accelerate biofuel integration. With these policy drivers in place, including CORSIA, there is an exigency for research into the feasibility of expanding aviation biofuel supply chains both domestically and internationally.

Building on prior work by Davis et al. [3], this paper applies a systems-based approach to model aviation biofuel distribution to Washington Dulles International Airport.

III. Technical Approach

A. Negotiations Among Supply Chain and Aviation Entities

The power-interest matrix is a typical framework utilized to map the relationships between different stakeholders in a network across two dimensions: their decision-making power in terms of being in the strongest position to affect outcomes (power); their need to be kept informed to provide expert background information, user requirements, and non-functional requirements (interest) [13]. In considering the context of this study, it became necessary to adjust the traditional power-interest matrix to account for three different, yet complementary, dimensions: engagement, financial potency, and time horizon, indicating the urgency for stakeholder investment. This EFHA (Engagement, Financing, and Time Horizon Analysis) framework provides a three-dimensional ranking of major biofuel stakeholders, outlined in Table I, on a 1-10 scale, with 1 being "low", 5 being "medium", and 10 being "high". The higher a ranking assigned, the larger the influence the stakeholder has on altering the aviation biofuels industry in the region. The rankings were constructed as follows:

- Engagement: Counts of Industry Partnerships and/or Physical Infrastructures
- Financing: Amount of Liquid Assets that Could be Available for Investment
- Time Horizon: Time Horizons for Critical Investments

For each of the three metrics, a rating of one to four is considered "low," whereas a rating of five to seven is considered "medium," and a rating of eight to ten is considered "high". A "low" rating for each metric translates to zero to five industry partnerships and/or physical infrastructures (Engagement), \$0 to \$10k immediately available for investment into aviation biofuels (Financing), and months to a months-to-a-year time frame commitment for vital investments (Time Horizon). A "medium" rating for each metric translates to six to ten industry partnerships and/or physical infrastructures, \$100k to \$10M, and up to a decade. A "high" rating for each metric translates to at least eleven industry partnerships and/or physical infrastructures, above \$10M, and a time frame of over one decade of necessary commitment to aviation biofuel production. Together, these make up the ratings seen in Table I.

TABLE I. Strategic Partners of Aviation Biofuel Supply Chains and Their Abbreviations

Abbreviation	Stakeholder	Engagement, Financing, Time Horizon Rating
AR	Academic Researchers	2, 1, 3
AC	Airline Companies	7, 8, 9
AM	Aircraft Manufacturers	3, 7, 4
ASCENT	The Aviation Sustainability Center	10, 2, 10
BP	Biofuel Producers	10, 4, 10
CAAFI	Commercial Aviation Alternative Fuels Initiative	10, 2, 10
CPM	Co-Product Manufacturers	2, 8, 7
DOE	U.S. Department of Energy	5, 8, 3
EG	Environmental Groups	2, 1, 5
EU	European Union	6, 9, 9
FAA	Federal Aviation Administration	8, 6, 9
FD	Fuel Distributors	3, 7, 5
FS	Fuel Storage	8, 5, 10
ICAO	International Civil Aviation Organization	7, 4, 9
IN	Investors	2, 10, 6
MWAA	Metropolitan Washington Airports Authority	5, 3, 9
VDOA	Virginia Department of Aviation	8, 3, 8
VOLPE	VOLPE National Transportation Systems Center	7, 1, 7

Academic researchers, for example, were low on the Engagement scale because, in the overarching realm of academia, relatively few institutes of higher education or universities dedicate time, effort, and resources to researching aviation biofuels. The FAA was medium on the financing scale because their FY 2025 budget request for "Alternative Fuels for General Aviation" (the FAA program dedicated to research for alternative jet fuels) was $8.4M [14]. Biofuel producers were high on the Time Horizon scale because existing producers of biofuels need to invest time, effort, and capital in scaling up the production of alternative aviation fuels on a much longer timeframe than other entities in the system; biofuel producers are a key component of securing the alternative aviation fuel supply chain [15].

For the case study represented by this paper, the next step in developing an understanding of the relationships between supply chain and aviation stakeholders was to create a visual representation of these ratings. Fig. 2 utilizes four different features to highlight the stakeholders and ratings. The x-axis scales up from left to right in Time Horizon, indicating a higher urgency for long-term investment for entities found further to the right; the y-axis scales up in Engagement, indicating higher interest in the aviation biofuels industry for entities found further up in the figure; each entity (represented by the points) is scaled by size based on their financial capacity for endowing the industry, with larger points indicating more liquid resources; and each point is colored based on which segment of the aviation industry the stakeholder is part of: blue signals a public entity (i.e. national/international governments), purple signals a private entity, and orange signals other stakeholders that represent amalgamations of other individual entities (i.e. groups or coalitions).

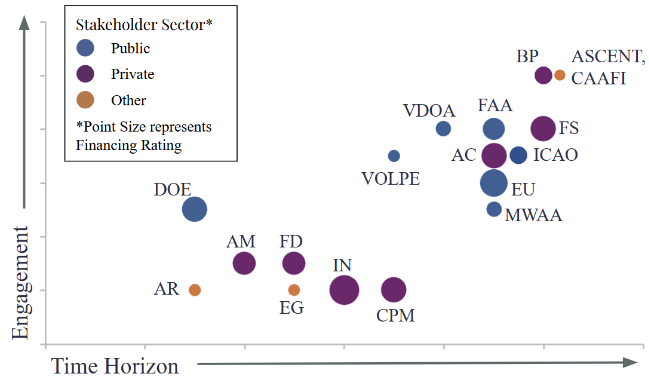

Fig. 2. Engagement vs Time Horizon Ratings of biofuel stakeholders, with representation of stakeholder financing based on symbol sizing.

In diagramming negotiations among the industry entities in this manner, it was possible to extrapolate some key observations and pinpoint one overarching theme. First, there are two main groupings of stakeholders: one that depicts a slight direct relationship between Time Horizon and Engagement, clustered at the higher end of the spectrum for both, and one that depicts an inverse relationship between Time Horizon and Engagement, clustered at the lower end of the spectrum. However, these clusters show no other similarity along the Financing or industry segment metrics, which suggests that financial investment and public versus private status are not indicative of whether a stakeholder will be highly engaged in the present or require a long-term investment into biofuel production.

A primary takeaway, however, is an appreciation for the complexity of stakeholder relationships when considering establishing new production of aviation biofuels in the region and formulating an efficient, resilient supply chain for transporting fuel to the airport. Such an effort to implement an advanced aviation biofuel industry in the region requires commensurate attention to collaboration and coordination.

B. Supply Chain & Logistics Analysis with Scenarios

The Freight and Fuel Transportation Optimization Tool (FTOT) tests and optimizes supply chain scenarios for the United States, and the developers provided a beta version of a tool designed for aviation biofuel sourcing, conversion, transportation, and blending to this project [16]. This tool was used to develop scenarios for estimating the cost of supplying aviation biofuels to the airport. The tool has a variety of variables that allow for differentiation between scenarios, including a market scenario, as defined by the Department of Energy [17], regions from which to source feedstock, types of feedstock, feedstock availability, processing technology, blenders, and airports. The constants were market scenario (mature-market medium), conversion process (Fischer-Trope), plant type (pioneer), blenders (within 75 miles of the airport), and airport (IAD). The dependent variable and index of performance is system cost. System cost is a weighted calculation of monetary resources required to generate and supply the biofuels to the ultimate destination, unmet demand, and emissions. Because of the resource constraints of developing and running each scenario, a fractional factorial design was implemented for this experiment. To develop a foundation for future scenarios, a simulation was run to observe viable paths for future analysis. The tool first determines locations and amounts of feedstock available from each potential source, as well as possible feedstock processor locations. Fig. 3 shows these two maps.

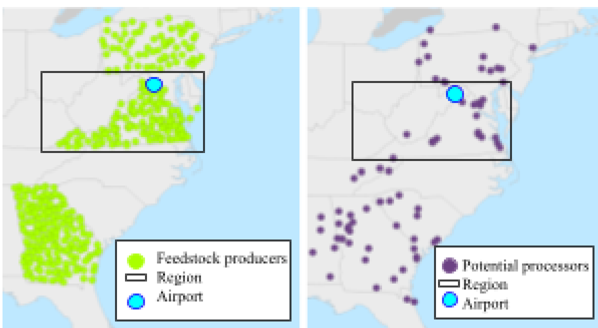

Fig. 3. Feedstock producers and candidate processors in the supply of biofuels to an international airport.

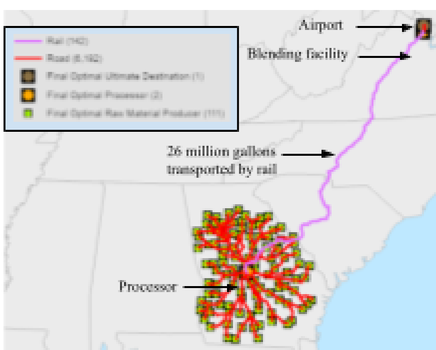

Fig. 4 Final optimal route showing optimum feedstock producers, all routes used, mode of transportation, final destination, optimum processor location, and blending facility.

The optimization tool then determined which processor location(s) best served to minimize the system cost metric. This was done using a linear algebra minimization function to find the optimum route from a processor to available blenders and, from there, to the airport. The final route is shown in Fig. 4. This figure demonstrates that the optimum mode of delivery of unblended biofuels to the airport was from outside the region, using both rail and road, given the simulation specifications. The supply chain produced 26 million gallons of unblended biofuel, fulfilling 53% of the set demand. Further analysis took into account previous research into regional feedstock advantages [3], new technologies [18], and previously existing or planned biofuel facilities and supply chains [19].

TABLE II. Supply Chain Optimization Scenarios by Independent Variables

Scenario	Feedstock	Demand	Source
S0. Baseline	known	low	regional
S1. High demand	known	high	regional
S2. Traditional	known	low	traditional
S3. Traditional with high demand	known	high	traditional
S4. Emerging	emerging	low	regional

From the results of this foundational scenario, our analysis was developed to compare the cost of multiple variations of the supply chains representing solutions for the airport. Table II shows the scenario breakdowns. The scenarios used either a known or emerging feedstock, high or low demand, and regional or traditional sources of feedstock. The factors were selected based on the likelihood of implementation, unique client value, and the ability for scenarios to be dominated and therefore ruled out by others. Table III provides a summary of the results.

TABLE III. Summary Results for Supply Chain Optimization Scenarios

Scenario	Supply used	Processors used	Capacity	Demand fulfilled
S0. Baseline	44%	1	80%	18%
S1. High demand	44%	1	80%	6%
S2. Traditional*	99%	1	75%	16%
S3. Traditional with high demand	97%	13	86%	81%
S4. Emerging	57%	5	92%	100%

*Error with criteria input produced incorrect results for scenario S2

Regional sources using known feedstock technologies were insufficient for meeting low or high demand in any meaningful way. Traditional feedstock producers for the known feedstock offered 5.5 million tonnes, even with a reduced feedstock availability factor of 900,000 tonnes offered regionally with a large feedstock availability factor [20]. The results from Table III reflect a preference for (S3) Traditional with high demand and (S4) Emerging. A comparative cost analysis of (S3) and (S4) was conducted using movement and process costs from [21] and [22]. Table IV shows data from this comparative analysis.

The system cost of CO_2 was set at 191 USD/ton [23]. Jet Fuel releases 9.75 kg CO_2 per gallon [24]. This comparative analysis shows the control to be the optimum solution. However, build cost will move to zero for (S3) and (S4) over time, the social cost of carbon increases with time, and the process cost will decrease as facilities become more efficient in producing biofuels. Adjusting the weights for these factors to match developing scenario characteristics could make biofuel supply chains preferred alternatives in the future.

TABLE IV. Comparative Cost Analysis of (S3) and (S4) with Control of 0% Biofuel Blend in $/gal [25]

Scenario	Build	Emissions	Movement	Process	Total - Build	Total
Control. 0% biofuel blend	-	2.16	-	1.91	4.06	4.06
S3.	8.67	0.62	0.99	12.47	14.03	22.75
S4.	6.00	0.78	0.49	3.75*	5.02	11.02

*Average between a range of $2.00 and $5.50 per gallon

C. Resilience Analysis With Disruptions of System Order

This resilience analysis utilized in this paper demonstrates an enterprise risk management tool to systematically track sources of enterprise risk associated with fuel production, distribution, and integration into existing and hypothetical aviation infrastructure. By analyzing key processes - feedstock sourcing, fuel conversion, blending, storage, and consumption - and tracking disruptions of system order, the approach highlights interdependencies and potential vulnerabilities across the supply chain. The analysis identifies evaluation criteria, including feedstock utilization, feedstock diversification, supply proximity, unit fuel cost, emissions avoided, and business development. This approach to addressing risk as the disruption of system order promises to enhance resilience, align stakeholders, resources, and regulations, and facilitate the large-scale adoption of advanced fuels in the aviation sector [26].

After the evaluation criteria for the system are defined, the supply chain system components are listed: the Airport (IAD), In-Region Wood Resources, Out-of-Region Wood Resources, Wood Processing Facilities, Fischer Tropsch Refinery, Blending Facility (at IAD), Transportation modes (Colonial Pipeline, Rail, and Truck), Storage Facility (at IAD), In-Region Biofuel Production, and Out-of-Region Biofuel Production. The system components are assessed to see how well they address each criterion (feedstock utilization, feedstock diversification, supply proximity, unit fuel cost, emissions avoided, and business development); the selections are used in weighting component importance.

26 emergent conditions that affect the system being analyzed are listed. 5 scenarios for analysis of system disruptiveness are formed from the emergent conditions. The most impactful emergent conditions were Competing Feedstock Demands, Fuel/Refinement Pathway Does Not Meet ASTM, and Fuel Instability.

Next, the criteria are assessed to determine their relevance among the other criteria and to what degree experiencing the future scenarios listed changes the importance of the criteria. Fig. 5 shows a visual of the system components ranked by their criticality to system goals under the baseline and future scenarios, with 1 being the most critical and 12 being the least. The horizontal blue and red lines represent the potential ranking on the critical scale if the scenarios with emergent conditions are observed.

The tool inputs are determined based on current industry trends and might vary depending on the timeframe, region of interest, and/or altering stakeholder perspectives when determining variable values. This tool was used for guidance in determining potential disruptions to the biofuel supply chain and requires further analysis as industry conditions or airport/region choices change. There is the opportunity for future exploration using this tool with inputs based on historical biofuel supply chain disruption data.

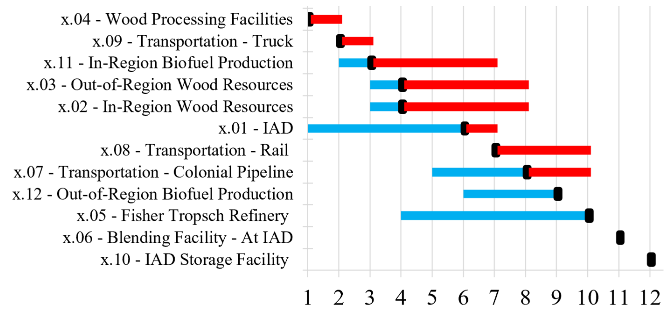

Fig. 5. Component ranking resilience analysis of biofuel supply chain to an international airport.

VI. Conclusions and Future Work

The above technical analysis suggests several key considerations and implications for the provision of biofuels to airports over the coming decades:

- **Stakeholder coordination is essential:** The EFHA framework revealed significant variation in stakeholder engagement, investment capacity, and urgency for action, underscoring the need for early and targeted collaboration among high-leverage actors.
- **Regional sources are insufficient alone:** Modeling showed that relying solely on regional feedstocks under current conditions cannot meet projected fuel demands.
- **Infrastructure siting is critical:** Processor locations must be geographically central to diverse feedstock sources and accessible to existing transport infrastructure.
- **System resilience matters:** Disruption-based risk analysis emphasized the importance of criteria like feedstock diversification, emissions reduction, and ASTM pathway compliance in ensuring supply chain robustness.

Future work should prioritize increasing fuel production volume by expanding feedstock diversity, scaling processing capacity, and collaborating with emerging SAF programs to share infrastructure and accelerate innovation will be critical for offsetting early costs and enabling broader market adoption. Additionally, sensitivity analysis of the supply chain optimization scenarios and quantitative disruption scenarios can be performed to test supply chain resilience and examine how the price may increase and decrease with time, market fluctuation, and incentives.

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REFERENCES

[1] Aviation Benefits Beyond Borders, CORSIA explained, 2016. [Online]. Available: https://aviationbenefits.org/ environmental-efficiency/climate-acton/market-based-measures/corsia /corsia-explained/

[2] ICAO, CORSIA Eligible Fuels – Life Cycle Assessment Methodology, Jun. 2022. [Supporting Document] Available:https://www.icao.int/environmental-protection/CORSIA/Documents/CORSA_Eligible_Fuels/CORSIA_Supporting_Document_CORSIA%20Eligible20Fuels_LCA_Methodology_V5.pdf

[3] C. D. Davis, S. Sreekumar, R. Altman, A. F. Clarens, J. H. Lambert, and L. M. Colosi, "Geospatially explicit technoeconomic assessment of sustainable aviation fuel production: A regional case study in Virginia," Fuel Communications, vol. 19, p. 100114, 2024. doi: 10.1016/j.jfueco.2024.100114.

[4] L. Martinez-Valencia, M. Garcia-Perez, M. P. Wolcott, "Supply chain configuration of sustainable aviation fuel: Review, challenges, and pathways for including environmental and social benefits," Renewable and Sustainable Energy Reviews, vol. 152, p. 111680. doi:10.1016/j.rser.2021.111680

[5] U.S. Department of Energy, "U.S. Department of Transportation, & U.S. Department of Agriculture, SAF Grand Challenge Roadmap: Flight Plan for Sustainable Aviation Fuel", Sep. 2022. [Online]. Available: https://www.energy.gov/eere/bioenergy/sustainable-aviation-fuel-grand-challenge

[6] U.S. Department of Energy, "2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy", Jul. 2016. [Online]. Available: https://www.energy.gov/eere/bioenergy/2016-billion-ton-report

[7] Federal Aviation Administration, "U.S. Aviation Climate Action Plan", Nov. 2021. [Online]. Available: https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf

[8] A. Connelly, "Resilience and Lifecycle Analysis for Priority Setting of Aviation Biofuels", Ph.D. dissertation, Dept. of Engineering Systems and Environment, Univ. of Virginia, Charlottesville, VA, USA, 2021.

[9] C. G. Gacek, D. J. Gimbel, S. J. Longo, B. I. Mendel, G. N. Sampaio, and J. H. Lambert, "Managing operational and environmental risks in the strategic plan of a maritime container port," Tech. Rep., Dept. of Engineering Systems and Environment, Univ. of Virginia, Charlottesville, VA, USA, May 2021.

[10] A. Connelly, "Scenario Analysis for Priority-Setting in Disaster Planning and Biojet Fuel Infrastructure", M.S. thesis, Dept. of Engineering Systems and Environment, Univ. of Virginia, Charlottesville, VA, USA, 2013.

[11] Airlines for America, "U.S. Airlines Announce 3-Billion-Gallon SAF Production4 Goal," Sept. 9, 2021. [Online]. Available: https://www.airlines.org/news/u-s-airlines-announce-3-billion-gallon-sustainable-aviation-fuel-production-goal/

[12] European Parliament and Council of the European Union, Regulation (EU) 2023/2405 on ensuring a level playing field for sustainable air transport (ReFuelEU Aviation), Official Journal of the European Union, Oct. 2023. [Online]. Available: https://eur-lex.europa.eu/eli/reg/2023/2405/oj/eng

[13] E. Phiri, P. N. Rowley, R. E. Blanchard, "Addressing Challenges in Delivering Sustainable Rural Water Provision Using Solar Water Pumping in Malawi: A Stakeholder Analysis," Energies, vol. 16, p. 7758. doi: 10.3390/en16237758

[14] "Budget Estimates Fiscal Year 2025 Federal Aviation Administration Submitted for Use of the Committee on Appropriations," 2024. Available: https://www.transportation.gov/sites/dot.gov/files/2024-03/FAA_FY_2025 Budget_Request_508-v5.pdf

[15] "The future of sustainable aviation fuel: A path to sustainable skies." Carbon Click. https://www.carbonclick.com/news-views/the-future-of-sustainable-aviation-fuel-a-path-to-sustainable-skies (accessed Apr. 11, 2025).

[16] "Freight and Fuel Transportation Optimization Tool (FTOT)," Freight and Fuel Transportation Optimization Tool (FTOT), 2024. https://volpeusdot.github.io/FTOT-Public/ (accessed Apr. 08, 2025).

[17] "2023 Billion-Ton Report: An Assessment of U.S. Renewable Carbon Resources," 2024. Available: https://www.energy.gov/sites/default/files/2024-03/beto-2023-billion-ton-rport_2.pdf

[18] "IAG Announces Strategic Investment in Wastefront – Pioneers Turning Used Tyres into Sustainable Aviation Fuel," IAG. International Airlines Group, Jan. 22, 2025. Available:https://www.iairgroup.com/media/32uja44t/20250121_iag-wastefront-pressrelease-final.pdf

[19] "USA Bioenergy Announces Land Purchase in Bon Wier, Texas, for its $2.8 Bilion Sustainable Aviation Fuel Refinery," USA BioEnergy. Jan. 12, 2025. Available: https://usabioenergy.com/bon-wier-land-purchase

[20] BDO Zone Initiative, "Bon Wier, Texas – BDO Zone Rating Award," Oct. 19, 2022. Available: https://bdozone.org/rating_award/bon-wier-tx/

[21] "U.S. Gulf Coast Kerosene-Type Jet Fuel Spot Price FOB (Dollars per Gallon)," www.eia.gov. https://www.eia.gov/dnav/pet/hist/eer_epjk_pf4_rgc_dpgD.htm (accessed Apr. 13, 2025).

[22] S. Van Dyk and J. Saddler, "Progress in Commercialization of Biojet /Sustainable Aviation Fuels (SAF): Technologies and policies IEA Bioenergy Task 39," 2024. Available: https://www.ieabioenergy.com/wp-content/uploads/2024/06/IEA-Bioenergy-Task-39-SAF-report.pdf

[23] L. Watkins, "EPA Releases Updated, Elevated Estimates for the Social Cost of Greenhouse Gases," Environment, Land & Resources, Jan. 25, 2024.

[24] U.S. Energy Information Administration, "Environment - U.S. Energy Information Administration (EIA) - U.S. Energy Information Administration (EIA)," Eia.gov, Sep. 07, 2023. https://www.eia.gov/environment/emissions/co2_vol_mass.php

[25] M. K. Jeong, J. T. Richardson, and M. S. Talmadge, "A techno-economic analysis of six biofuel pathways using waste feedstocks for sustainable aviation fuel production," *Renewable and Sustainable Energy Reviews: Focus*, vol. 1, 2024, Art. no. 100003. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2666052024000037

[26] E. Connelly and J.H. Lambert, "Resilience analytics of a future supply chain for aviation biofuels," *Transp. Res. Rec.*, vol. 2600, no. 1, pp. 39–48, 2016. doi: 10.3141/2600-05