



Project 001(E) Alternative Jet Fuel Supply Chain Analysis

University of Tennessee

Project Lead Investigator

Timothy Rials
Professor and Associate Dean
AgResearch, University of Tennessee
2506 Jacob Dr., Knoxville, TN 37996
865-946-1130
trials@utk.edu

University Participants

University of Tennessee (UT)

- P.I.: T. Edward Yu, Professor
- FAA Award Number: 13-C-AJFE-UTenn, Amendments 22
- Period of Performance: October 1, 2024, to September 30, 2025
- Tasks:
 1. Estimate regional feedstock supply for sustainable aviation fuel (SAF)
 2. Analyze the risk factors reported by publicly traded biofuel companies
 3. Assess the stakeholder perceptions of the SAF supply chain for its deployment
 4. Collaborate with other ASCENT team members on feedstock supply and facility location analysis

Project Funding Level

Total estimated project funding: \$200,000

Total federal and non-federal funds: \$200,000

The UT Institute of Agriculture, in support of the project, provided faculty and staff salaries and graduate student tuition.

Investigation Team

Timothy Rials (Project Director – PD), Task 4
T. Edward Yu (P.I.), Tasks 1–4
Carlos Trejo-Pech (faculty), Task 2
Ricky Chen (faculty), Tasks 3
David Hughes (faculty), Task 3
Hannah Williams (Research Associate), Tasks 1 and 3
Bijay Regmi (MS student), Tasks 1 and 4
Bishal Bista (MS student), Task 2

Project Overview

UT leads the project's feedstock production analysis for the Southeast region of the United States (U.S.). This component targets the need to assess regional forest and agricultural biomass feedstock resources and delineate the sustainability impacts associated with feedstock choices. UT also leads the national lipid supply availability analysis to develop information on the potential effects and feasibility of using lipids to supply SAF. The UT team facilitates regional deployment and production of SAF by understanding stakeholders' perspectives throughout the SAF supply chain to expedite the development and scaling. Additionally, UT collaborates with other ASCENT team members on feedstock supply and facility location analysis.





Task 1 - Estimate Regional Feedstock Supply for Sustainable Aviation Fuel

University of Tennessee

Objectives

- Assess the impacts of feedstock quality on the supply chains and economics of SAF produced from logging residues via fast pyrolysis/hydrotreatment in the Southeast U.S.
- Develop a SAF supply chain from winter canola for the two major U.S. air cargo hubs: Memphis International Airport (MEM) and Louisville Muhammad Ali International Airport (SDF).

Research Approach

Using forestry biomass (e.g., logging residues) for SAF production to replace fossil-based jet fuel has been suggested as a potential means to mitigate carbon emissions from the aviation sector. However, the quality of the feedstock, particularly the ash content, can adversely affect bio-oil yield and SAF production using the fast pyrolysis/hydrotreatment process, and potentially its supply chain optimization. Previous research often assumes fixed biofuel yields and neglects the variability in feedstock quality when optimizing the supply chain. Thus, this study seeks to address this gap in the literature by employing a two-stage mixed-integer linear programming (MILP) model to investigate the influence of varying ash content in logging residues on the potential maximum supply quantity (MSQ) and net revenue (NR) of SAF production. Figure 1 presents the supply chain network and the modeling structure. Two scenarios were conducted in the Southeastern U.S.: (1) assuming constant ash content, and (2) accounting for the heterogeneous ash content in logging residues.

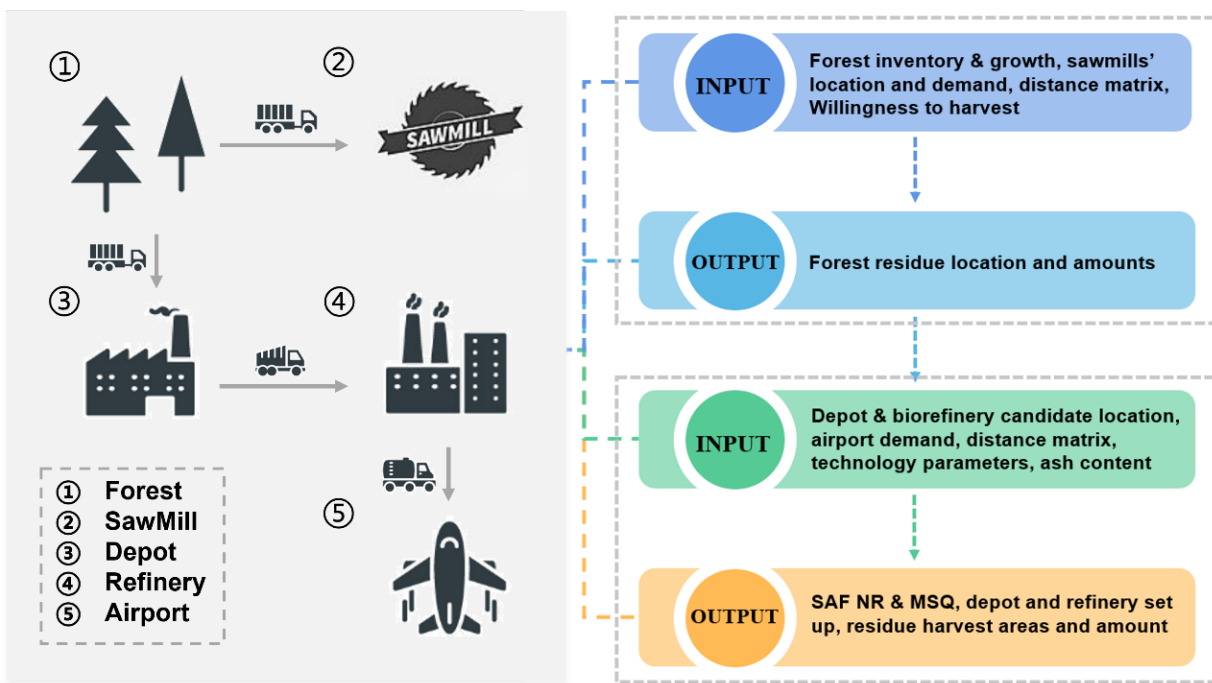


Figure 1. Diagram of logging residue-based SAF supply chain network and model structure.
Note: NR: net revenue; MSQ: maximum supply quantity.

In addition to biomass feedstock, intermediate crops cultivated during winter have gained recent attention as SAF feedstocks via the hydro-processed ester fatty acid (HEFA) pathway. We applied our previously established winter canola supply chain optimization model to evaluate the economic and potential volume of SAF to two major U.S. air cargo hubs, i.e., MEM and SDF airports. We have been expanding the cultivation area beyond Tennessee and Kentucky when locating winter canola production areas around those two major air cargo hubs.



Milestones

- Completed and presented the results of the forestry biomass for SAF production and developed a manuscript that has been revised and resubmitted.
- Updated the winter canola data files and incorporated them with the winter canola supply chain model.

Major Accomplishments

The impact of incorporating feedstock ash content variability on the economic and supply chains of the optimization model is considerable. Table 1 summarizes the differences in the optimal logging residue supply chain outputs between the fixed ash content case and heterogeneous ash case. The lower SAF production and higher production cost when considering ash content variations in logging residues are due to lower conversion throughput (i.e., lower bio-oil yield from the same amount of logging residues) in areas with high ash content. Neglecting ash variations in feedstock and using a constant ash content and fixed bio-oil yield likely overestimates feedstock availability and the corresponding SAF production, as shown in the constant ash content scenario.

Table 1. Optimization outputs of the assuming fixed and heterogeneous ash contents in logging residues.

	No Ash Variation	Spatially Heterogeneous Ash Variation	Difference
Annual SAF Production (million gal)	629.	540	↓89 (-14.10%)
Other Biofuels (million gal)	446	384	↓62 (-13.90%)
Number of Biorefineries	18	16	↓2
Avg. Biorefinery Capacity (million gal/year)	80	77	↓3 (-3.75%)
Number of Depots	85	80	↓5
Total Production Cost (\$/gallon)	5.76	5.92	↑0.16 (2.78%)
- Harvest Cost	0.38	0.41	↑0.03 (7.89%)
- Stumpage Coste	0.11	0.11	--
- Preprocessing Cost	1.44	1.55	↑0.11 (7.64%)
- Conversion Cost	3.25	3.25	--
- Transport: Site > Depot	0.37	0.38	↑0.01 (2.70%)
- Transport: Depot > Refinery	0.2	0.22	↑0.02 (10.00%)
- Transport: Refinery > Airport	0.02	0.02	--
SAF Selling Price (\$/gallon)	9.09	9.09	Fixed
Net Revenue (\$/gallon)	3.33	3.17	↓0.16 (-4.80%)

SAF: sustainable aviation fuel

As illustrated in Figure 2, the model selects 18 refineries under the constant-ash scenario (top panel). In contrast, the heterogeneous-ash scenario results in the selection of only 16 refineries (bottom panel), leading to the exclusion of two sites: Meriwether, GA (60 million gal) and Cleveland, NC (60 million gal). Additionally, one site is relocated from Wilson, TN, to Davidson, TN, approximately 51 miles away. Among the remaining operational sites, the model adjusts facility capacity with notable disparities: one site reduces capacity by 30 million gal, two sites each downsize capacity by 20 million gal, two sites each lower capacity by 10 million gal, and only one site increases capacity by 10 million gal. Consequently, accounting for feedstock ash variability results in an overall reduction of 200 million gal in capacity compared to the constant-ash scenario.

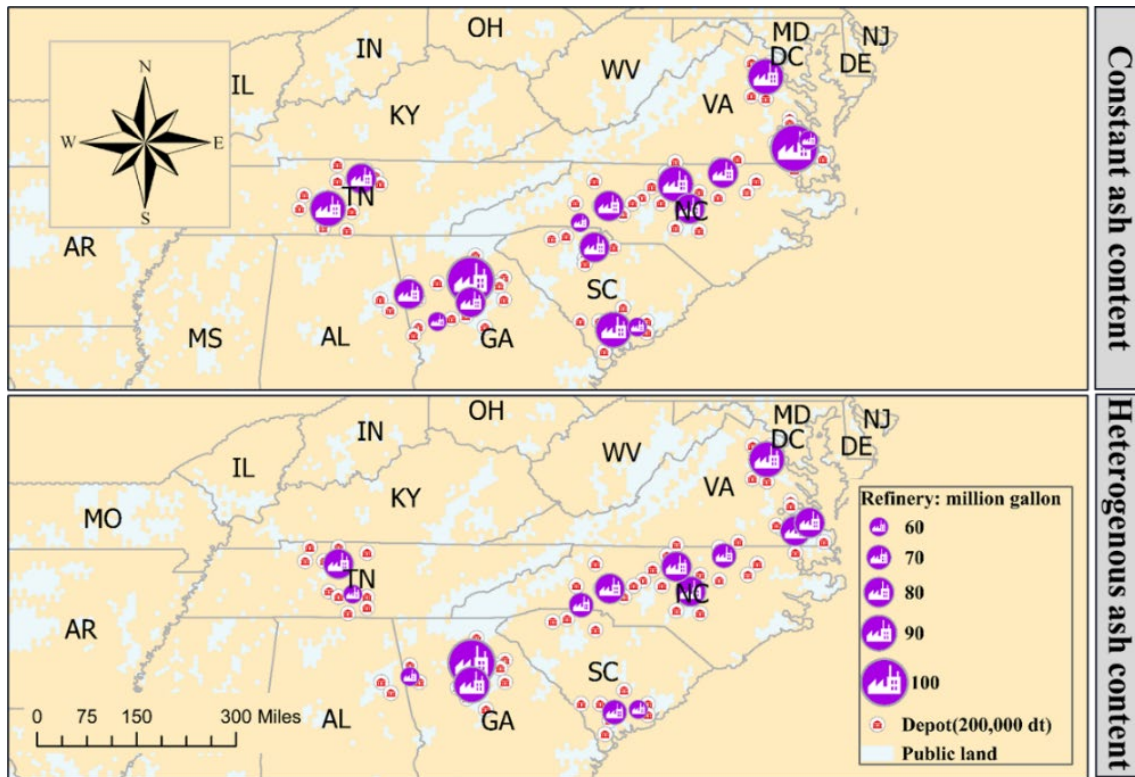


Figure 2. Graphic of placement comparison of preprocessing and conversion facilities.

Publications

Bolakhe, K., Yu, T. E., Sykes, V., Smith, A., & Boyer, C. N. (Manuscript revised and resubmitted for publication). *Assessing a Sustainable Aviation Fuel Supply Chain from Winter Canola and Its Carbon Intensity Considering Feedstock Yield Variations*.

Li, P., Yu, T.E., Labbé, N., Abdoulmoumine, N., Garcia-Perez, M., Hoyt, K.P., & English, B.C. (2026). Spatial Optimization of the Sustainable Aviation Fuel Supply Chains from Forest Residues via Fast Pyrolysis/Hydrotreatment Considering Feedstock Ash Content Variability. *Biomass and Bioenergy*, 208:108793. <https://doi.org/10.1016/j.biombioe.2025.108793>

Outreach Efforts

The study results have been disseminated at various professional meetings. Our team also shared the work with the Tennessee Department of Agriculture.

Conference Presentations

Yu, T. E. (2024, September 30 - October 3). *Biomass Feedstock Supply Chain Modeling and Decision Tools for Sustainable Aviation Fuels* [Conference presentation]. 2024 Frontiers in Biorefining 7th International Conference, St. Simons Island, Georgia.

Yu, T. E., Li, P., Labbé, N., Abdoulmoumine, N., Garcia-Perez, M., & Hoyt, K. (2024, November 20-22) *Sustainable Aviation Fuel Supply Chains Optimization from Forest Residues Considering Feedstock Ash Content Variability* [Conference presentation]. 2024 AFCC Global Biobased Economy Conference, Washington DC.

Awards

2025 Outstanding Master's Thesis Award for Kumar Bolakhe's master's thesis, titled "Stochastic Optimization of Canola-Based Sustainable Aviation Fuel in the Southeastern US," awarded by the Southern Agricultural Economics Association.



2025 Outstanding Master's Thesis Award Honorable Mention for Kumar Bolakhe's master's thesis, titled "Stochastic Optimization of Canola-Based Sustainable Aviation Fuel in the Southeastern US," awarded by the Agricultural and Applied Economics Association.

Student Involvement

Kumar Bolakhe, a previous MS student, developed the winter canola supply chain optimization model. Bijay Regmi, a current MS student, is updating the data files for the winter canola supply chain for the major air cargo hubs.

Plans for Next Period

- Continue to work on regional SAF analysis using winter canola as feedstock.
- Incorporate life-cycle analysis to supply chain analysis.

Task 2 - Analyze the Risk Factors Reported by Publicly Traded Biofuel Companies

University of Tennessee

Objectives

One of the biggest challenges in an emerging industry is the significant uncertainty investors face. Given the high level of uncertainty in the immature biofuel industry, such as SAF, the primary objective of this study was to identify and assess the risks biofuel firms face. The study evaluated the risk factors, or specific risks, reported by biofuel firms to the U.S. Securities and Exchange Commission (SEC).

Research Approach

This study analyzed the risks disclosed by a sample of biofuel firms that listed their securities on U.S. exchange markets. The study primarily evaluated two risk metrics, prevalence and relevance, across 25 specific risks (or risk factors) listed in Table 2 and Table 3 from 2017 to 2021. Risk prevalence measures the extent to which a risk affects the biofuel industry. It represents the number of firms in the sample that report a particular risk each year, or equivalently, the proportion of firms that report it. Risk relevance measures the severity of a risk by considering the frequency with which a risk is reported/discussed by firms in their annual reports, as well as the importance or priority assigned by firms to that particular risk. The risk relevance metric was validated by comparing it with other widely used risk metrics, including the Z-score and the debt-to-equity ratio, which typically measure overall firm risk. The analysis was conducted for all firms in the sample, as well as for subsets of focused and diversified biofuel firms. Identification of risk metrics by quadrants, combined with quantile regression analysis, allowed us to identify the critical risks.

Table 2. External risk factors analyzed in the study.

Political	Economic	Social	Technological
Biofuel regulation	Feedstock markets	Public opposition	Conversion technology
Environmental	Biofuel markets	Public perception	Fuel compatibility
Infrastructure	Competing fuel markets		Intellectual property
International	Energy markets		Cybersecurity
General regulations	Competition		
	General economic conditions		
	Stock price risk		



Table 3. Primary activities and support activities risk factors analyzed in the study.

Primary Activities	Support Activities
Facilities development	General management
Profitable operations	Risk management
	Financing
	Contracting
	Mergers and acquisitions

Milestones

- Performed risk analysis of the publicly traded biofuel firms.
- Published a peer-reviewed journal article for this study.

Major Accomplishments

Figure 3 plots the medians of prevalence (panel A) and relevance (panel B) by risk category. Primary activities, support activities, economic, and political sources of risk were ranked above or around the median values of the biofuel industry. In contrast, the social and technological risk categories were below the overall medians. Figure 3 suggests that firm managers consider internal factors, classified into primary and support activities, more relevant than external factors, likely because managers are more exposed to daily internal activities than to external factors, which are considered in less frequent strategic management assessments.

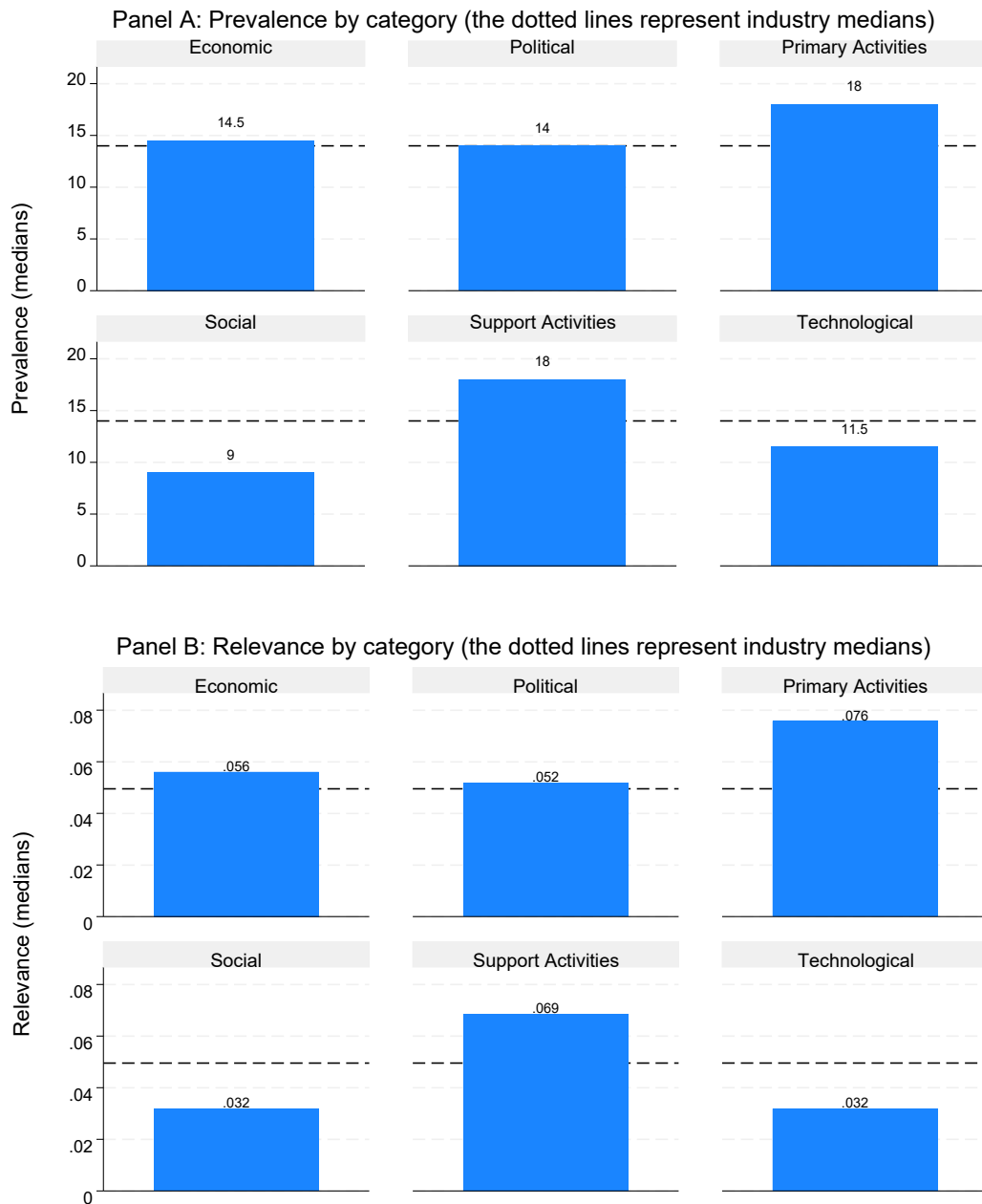


Figure 3. Prevalence and relevance by risk category for biofuel firms over 2017-2021.

The quantile regression results, presented in Table 4, help us identify critical risks. The dependent variable for the regression was the risk metric relevance, and the explanatory variable was the binary variable created for each risk. A risk was identified as critical if the risk's relevance median was statistically equal to or higher than the median of all other risks in the quantile regression. The critical risks included biofuel regulation, biofuel markets, feedstock markets, conversion technologies, profitable operations, financing, and risk management. Environmental and contracting risks were also critical.



Table 4. Regressions for risk relevance of biofuel firms from 2017 to 2021.

	Risk relevance (medians)		Regression coefficient
	In the group	Not in the group	
<u>Political:</u>			
Biofuel regulation	0.0777	0.0474	0.0303***
Environmental	0.0474	0.0493	-0.002
Infrastructure	0.0381	0.0503	-0.0122***
International	0.0517	0.0490	0.003
General regulations	0.0669	0.0474	0.0195**
<u>Economic:</u>			
Feedstock markets	0.0694	0.0474	0.022***
Biofuel markets	0.1117	0.0474	0.0644***
Competing fuel markets	0.0514	0.0490	0.002
Energy markets	0.0496	0.0475	0.002
Competition	0.0475	0.0493	-0.002
General economic conditions	0.0753	0.0474	0.028***
Stock price	0.0291	0.0503	-0.0212***
<u>Social:</u>			
Public opposition	0.0250	0.0503	-0.0253***
Public perception	0.0375	0.0503	-0.0128***
<u>Technological:</u>			
Conversion technology	0.0442	0.0503	-0.006
Fuel compatibility	0.0315	0.0503	-0.0188*
Intellectual property	0.0246	0.0503	-0.0257***
Cybersecurity	0.0369	0.0503	-0.0134***
<u>Primary Activities:</u>			
Facilities development	0.0519	0.0475	0.004
Profitable operations	0.1010	0.0474	0.0536***
<u>Support Activities:</u>			
General management	0.0421	0.0503	-0.0082**
Risk management	0.1438	0.0474	0.0964***
Financing	0.0957	0.0474	0.0483***
Contracting	0.0759	0.0474	0.0286**
Mergers and acquisitions	0.0345	0.0503	-0.0158***



Publications

Peer-Reviewed Journal Publication

Trejo-Pech, C. O., Bista, B., Yu, T. E., & Larson, J. A. (2025). An Analysis of the Risk Narrative Disclosed by Publicly Traded Biofuel Firms. *Energy Strategy Reviews*, 62, 101927. <https://doi.org/10.1016/j.esr.2025.101927>

Outreach Efforts

The preliminary findings were shared with some biofuel companies for feedback.

Awards

None.

Student Involvement

An MS student, Bishal Bista, calculated the risk metrics in the study.

Plans for Next Period

The analysis could be updated with more recent data if additional funding is available.

Task 3 - Assess the Stakeholder Perceptions of the SAF Supply Chain for its Deployment

University of Tennessee

Objectives

The UT team facilitates regional deployment and production of SAF by understanding stakeholders' perspectives throughout the SAF supply chain to expedite its development and scaling.

Research Approach

For airlines to commit to using SAF, there must be reliable consumer demand. This study evaluated whether airline campaign videos could change consumers' perceptions and understanding of SAF and their willingness to pay a premium. We surveyed American air travelers who were adults and had flown at least once in the past year, using an international market research company (Qualtrics) in February 2025. The study involved two airline campaign videos: Delta Air Lines and United Airlines, which served as the treatment groups. A total of 1,327 valid responses were collected, with 444 participants viewing Delta Air Lines' campaign video, 445 participants watching United Airlines' video, and 438 participants in a control group. We also used the best-worst scaling (BWS) analysis to identify what features of SAF are most and least important to U.S. air travelers.

Major Accomplishments

Figure 4 indicates that the campaign videos increased respondents' acceptance of SAF. The blue bar represents the control group that did not watch either of the campaign videos. The yellow bar refers to the treatment group before watching the video, while the green bar represents the treatment group after watching the video. For both statements in the figure, the share of choosing "strongly agree" significantly increased, while the share of "neither agree nor disagree" group decreased.



It is important for airlines to use SAF

The aviation industry could achieve net-zero carbon emissions by using SAF

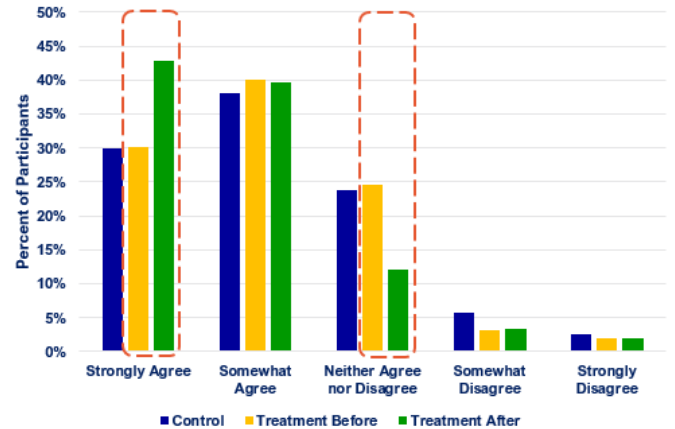
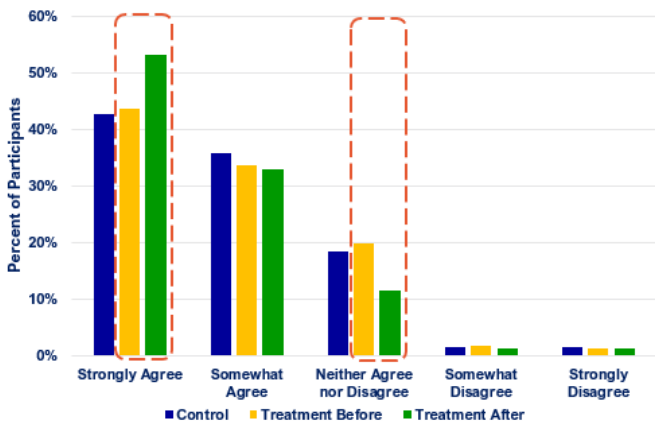


Figure 4. Charts of air travelers’ perceptions about the importance of using sustainable aviation fuel (SAF) for flights.

Figure 5 presents the impact of the campaign video on air travelers’ knowledge of SAF. The distribution of respondents’ knowledge clearly shifted right. Most respondents received four points before watching the video. However, after watching the video, more than 70% of respondents received scores greater than five points. Table 4 shows more details about the composition of the changes. The videos improved the overall knowledge scores by nearly 41%, with more than 68% of the respondents knowing more about SAF after treatment. Interestingly, the video impact varied slightly by airline. Knowledge of both SAF benefits and feedstocks improved, with more progress on feedstocks.

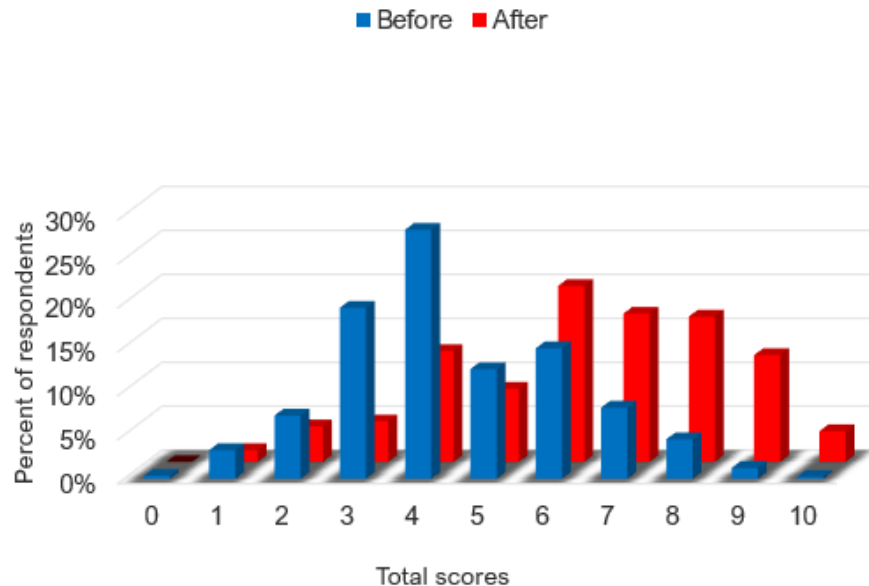


Figure 5. Graph of U.S. air travelers’ knowledge scores about SAF before and after the campaign video.



Table 5. Summary of U.S. air travelers' knowledge before and after the campaign video.

Group Name	Total Scores before Treatment	Total Score after Treatment	Percent of Improved Total Scores	Number of People with Improved Scores	Number of People in Group	Percent of People with Improved Score
Overall	3974	5601	40.94%	612	889	68.84%
Airline Campaign Subgroups:						
Delta	2017	2846	41.10	316	444	71.17%
United	1957	2755	40.78%	296	445	66.52%
SAF Question Subgroups:						
Benefits	2654	2814	6.03%	287	889	32.28%
Feedstocks	1320	2787	111.14%	580	889	65.24%

Figure 6 shows most of the participants were willing to pay a premium for their last flight if fueled by SAF. Also, participants who purchased higher-class tickets were willing to pay a larger premium. For instance, most air travelers who paid their last air ticket prices less than \$1,000 were willing to pay the SAF premium up to 10% of the ticket price. However, travelers who paid more than \$1,500 for the last ticket were willing to pay a much higher premium.



Figure 6. WTP for SAF premium vs. price paid for the last ticket.

Regression analysis in Table 6 revealed that respondents who better understood SAF's benefits from the campaign videos were more inclined to pay the premium. Furthermore, age, gender, education, the number of flights taken per year, air ticket prices, and awareness of changing weather patterns influenced the willingness to pay the premium. Our findings suggest that improving public perception and knowledge of SAF is essential for its further development.



Table 6. Regression results of the willingness to pay (WTP) for sustainable aviation fuel (SAF) premium.

Variables	Model 1	Model 2	Model 3
Air ticket price paid last flight	0.33 (0.033)***	0.32 (0.032)***	0.32 (0.033)***
Number of flights last year	0.17 (0.048)***	0.16 (0.049)***	0.16 (0.048)***
Age	-0.13 (0.016)***	-0.12 (0.16)***	-0.12 (0.016)***
Gender	-0.29 (0.100)**	-0.26 (0.102)*	-0.26 (0.102)*
Education	-0.05 (0.034)	-0.05 (0.034)	-0.05 (0.034)
Weather pattern change	0.048 (0.073)***	0.47 (0.073)***	0.048 (0.074)***
Delta	0.14 (0.122)	--	--
United	-0.05 (0.124)	--	--
Δ in benefit scores	--	0.08 (0.031)**	0.08 (0.031)**
Δ in feedstock scores	--	-0.09 (0.028)***	-0.09 (0.028)***
Perception Δ of importance of SAF	--	--	0.18 (0.084)*
Perception Δ of NetZero from SAF	--	--	0.08 (0.031)
LR chi2(8)	297.89	308.63	311.39
Prob>chi2	0.000	0.000	0.000

Note: N=1326; standard errors in parenthesis;

* p<0.05, ** p<0.01, *** p<0.001

The BWS analysis results, presented in Figure 7, show that carbon emission reduction and local air quality improvement are the top two features of SAF considered by U.S. households. Findings suggest that consumers prioritize the environmental benefits of SAF over other features. This perspective remains largely consistent across various demographics, including both those who watched and did not watch the SAF videos, as well as across genders and age groups.

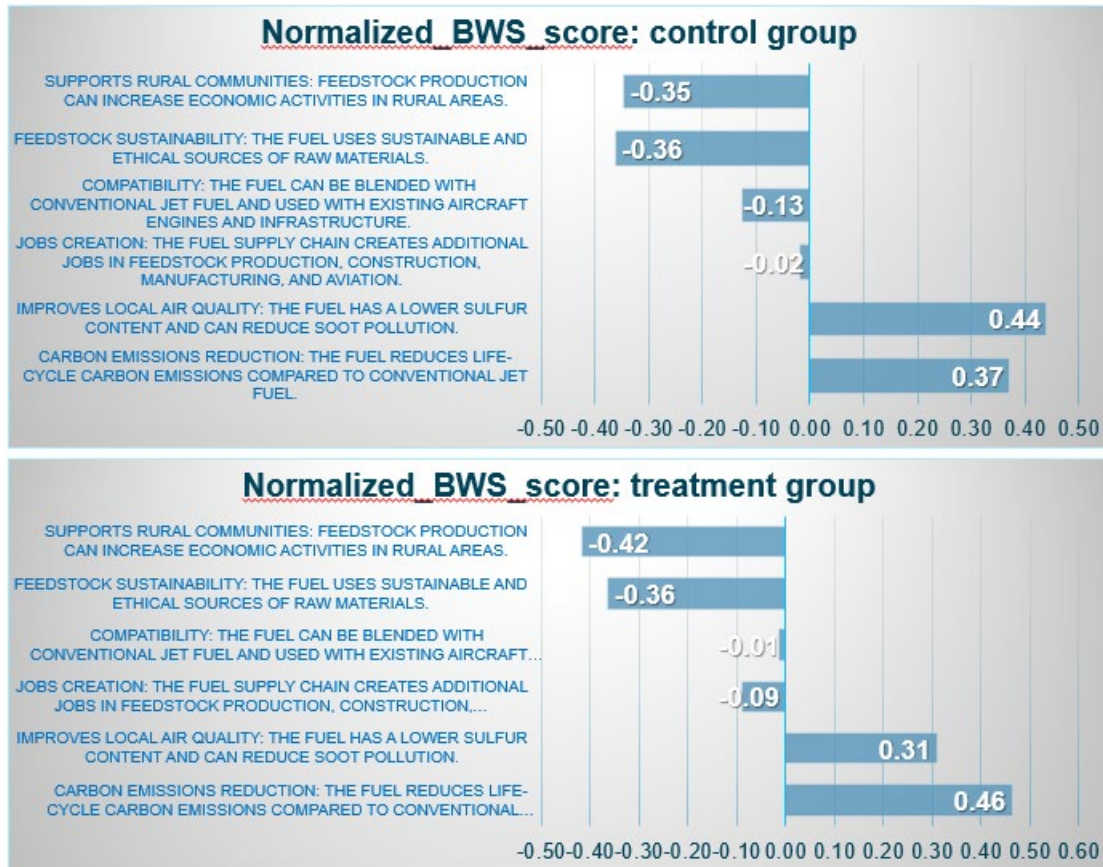


Figure 7. Chart of the best-worst scaling analysis results of the SAF features.

Publications

None.

Outreach Efforts

We shared our findings with an industry group (Airlines for America) and government agencies for their feedback and input.

Conference Presentation

Yu, T. E., Meyer, E., & Chen, X. (2025, July 9-11). *Consumers' Perception and Knowledge of Sustainable Aviation Fuel and Their Willingness to Pay a Premium* [Conference presentation]. The 1st International Conference on Sustainable Aviation Research, Dublin, Ireland.

Awards

Best Paper Award, International Conference of Sustainable Aviation Research, 2025 (Yu et al., 2025).

Student Involvement

An undergraduate student, Emma Meyer, participated in the survey design and analysis, and composed an undergraduate thesis titled "The Impact of Airline Campaign Video on Consumers' Perception and Knowledge of Sustainable Aviation Fuel and Their Willingness to Pay."



Plans for Next Period

- Develop manuscripts from the survey results to examine the impacts of airlines' SAF campaign videos on air travelers' perception and knowledge about SAF and their willingness to pay for SAF premium.

Task 4 - Collaborate with other ASCENT Team Members on Feedstock Supply and Facility Location Analysis

University of Tennessee

Objective

Collaborate with other ASCENT Project 001 teams, e.g., U.S. Department of Transportation Volpe Center (Volpe) or Washington State University (WSU), to conduct feedstock supply and facilitate location analysis.

Research Approach

This task involves exchanging necessary input with other teams through research efforts. The approach varies based on the topic and scope of research.

Milestones

- Worked with WSU in Techno-economic Analysis (TEA) assessment and the impact of government programs on oilseed markets
- Worked with Volpe to examine the Freight and Fuel Transportation Optimization Tool (FTOT) model for winter canola supply chains.

Major Accomplishments

We obtained some preliminary output but will need to further examine the analyses.

Publications

None.

Outreach Efforts

None.

Awards

None.

Student Involvement

Bijay Regmi, an MS student, has worked closely with Volpe to validate the winter canola supply chains from FTOT.

Plans for Next Period

Finalize the analysis with WSU and develop a manuscript of the oilseed analysis.