

Project 001(D) Alternative Jet Fuel Supply Chain Analysis

The Pennsylvania State University

Project Lead Investigator

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University Participants

The Pennsylvania State University

- P.I.: Lara Fowler, Interim Director, Penn State Sustainability Institute; Professor of Teaching, Penn State Law
- P.I.: Saurabh Bansal, Associate Professor of Supply Chain Management (through funding period ending January 31, 2022)
- P.I.: Anne Menefee, Assistant Professor of Energy and Mineral Engineering (starting with funding period beginning June 14, 2022)
- P.I.: Armen Kemanian, Professor of Production Systems and Modeling (starting with funding period beginning June 14, 2022)
- P.I.: Tom Richard, Professor of Agriculture and Biological Engineering (starting with funding period beginning June 14, 2022)
- Researcher: Ekrem Korkut, Legal Research Postdoctoral Associate
- FAA Award Number: 13-C-AJFE-PSU, RISK-INFORMED ALTERNATIVE JET FUEL (AJF)
- Periods of Performance: period A: August 1, 2017 to January 31, 2022; period B: June 14, 2022 to November 13, 2023
- Tasks:

Period A (August 1, 2017 to January 31, 2022)

1. 1.3.1: Risk-reward profit-sharing modeling for first facilities
- 1.3.2: Additional quantification of risk and uncertainties in supply chains (foundational part of Task 1.3.1)
- 1.3.3: Supply chain risk analysis tools for farmer adoption
- 1.4.1: National survey of current and proposed state and federal programs that monetize ecosystem services
- 1.4.3: Support of stakeholder engagement efforts

Period B (June 14, 2022 to November 13, 2023)

- 1.1: Research on existing federal law and policy drivers
- 1.2: Research on existing state and regional law and policy drivers
- 1.3: Research on proposed legislation (federal and state)
- 1.4: Research on other law/policy issues, as identified by the ASCENT 001 team
2. 2.1: Work with ASCENT 001 to identify stakeholder engagement opportunities
- 2.2: Development of a list of potential stakeholders critical to discussion
- 2.3: Development of agenda/materials for critical discussions; meeting facilitation as needed
3. 3.1: Work with ASCENT 001 team members to identify critical questions, and refine the scope of work related to carbon capture and sequestration (CCS)

- 3.2: Conduct literature review regarding CCS and its potential use in conjunction with alternative jet fuels (AJFs)
- 3.3: Draft a review manuscript examining opportunities to integrate CCS and AJF
- 4. 4.1: Work with ASCENT 01 team members to identify critical questions, and refine the scope of work related to soil organic carbon
- 4.2: Conduct literature review regarding soil organic carbon and its potential relation to AJF
- 4.3: Draft review manuscript examining opportunities for organic soil carbon and AJF.

Washington State University (WSU)

- Michael Wolcott, Regents Professor (for funding period from June 14, 2022 to November 13, 2023)
- Kristin Brandt, Staff Engineer (through funding period ending January 31, 2022)

University of Tennessee

- Tim Rials, Associate Dean of Agricultural Research (through funding period ending January 31, 2022)
- Burt English, Professor of Agricultural and Resource Economics (through funding period ending January 31, 2022)

Project Funding Level

FAA funding: \$100,000 (for period B, June 14, 2022 to November 13, 2023)

Matching from Penn State: \$100,000

Total funding: \$200,000

Investigation Team

Period A (August 1, 2017 to January 31, 2022)

Task 1.3.1 (Bansal; supported by Brandt and English): Risk-reward profit-sharing modeling for first facilities

Task 1.3.2 (Bansal; supported by Brandt and English): Additional quantification of risk and uncertainties in supply chains (foundational part of Task 1.3.1)

Task 1.3.3 (Bansal; supported by Brandt and English): Supply chain risk analysis tools for farmer adoption

Task 1.4.1 (Fowler; supported by Korkut): National survey of current and proposed state and federal programs that monetize ecosystem services

Task 1.4.3 (Fowler; supported by Korkut): Support of stakeholder engagement efforts

Period B (June 14, 2022 to November 13, 2023)

Task 1.1 (Fowler, supported by Korkut): Research on existing federal law and policy drivers

Task 1.2 (Fowler, supported by Korkut): Research on existing state and regional law and policy drivers

Task 1.3 (Fowler, supported by Korkut): Research on proposed legislation (federal and state)

Task 1.4 (Fowler, supported by Korkut): Research on other law/policy issues, as identified by the ASCENT 001 team

Task 2.1 (Fowler, supported by Korkut): Work with ASCENT 001 to identify stakeholder engagement opportunities

Task 2.2 (Fowler, supported by Korkut): Development of a list of potential stakeholders critical to discussion

Task 2.3 (Fowler, supported by Korkut): Development of agenda/materials for critical discussions; meeting facilitation as needed

Task 3.1 (Menefee): Work with ASCENT 001 team members to identify critical questions, and refine the scope of work related to carbon capture and sequestration (CCS)

Task 3.2 (Menefee): Conduct literature review regarding CCS and its potential use in conjunction with alternative jet fuels (AJFs)

Task 3.3 (Menefee): Draft a review manuscript examining opportunities to integrate CCS and AJF

Task 4.1 (TBD, supported by Wolcott): Work with ASCENT 01 team members to identify critical questions, and refine the scope of work related to soil organic carbon

Task 4.2 (TBD, supported by Wolcott): Conduct literature review regarding soil organic carbon and its potential relation to AJF

Task 4.3 (TBD, supported by Wolcott): Draft review manuscript examining opportunities for organic soil carbon and AJF.

Project Overview

For the first period of performance (period A), this project focused on developing a qualitative and quantitative understanding of factors to help establish biofuel supply chains for AJFs. Although efforts are being made to establish these supply chains, many face challenges because of a lack of clarity regarding the incentives that stakeholders would require to engage in these supply chains and devote their resources to investing in the facilities required for these supply chains. To this end, this project has two goals:

1. Develop pro forma cash flows that represent the financial status of various participants in biofuel supply chains for AJFs, to inform a transparent risk-sharing tool
2. Understand the policy landscape in various parts of the United States to encourage AJF supply chains and identify additional policy initiatives that may be needed

During the second period of performance (period B), this project continues to focus on understanding the law and policy drivers associated with AJF, while expanding focus to include two new areas—CCS and organic soil carbon—and their potential linkages to AJF.

Period A, Task 1.3.1 - Risk-reward Profit-sharing Modeling for First Facilities

The Pennsylvania State University

Objective

Develop a transparent risk-sharing tool to provide all partners with an understanding of the cash flows and risks faced by all supply chain partners.

Research Approach

We first collected a large number of risk-sharing tools that have been proposed in the supply chain literature. Subsequently, we narrowed this list to 9–12 mechanisms. We created an Excel-based framework in which the cash flows of all supply chain partners are modeled on the basis of data from the techno-economic analyses developed by WSU. This framework incorporates the risk-sharing mechanisms.

Milestone

We developed Excel models for four realistic configurations by using data from techno-economic analysis models developed by WSU.

Major Accomplishments

We developed an Excel-based framework showing the cash flows of four key stakeholders in AJF supply chains: farmers, preprocessors, refineries, and airlines. The framework shows various risk-sharing contracts that each of the stakeholders could extend to others, as well as the financial burdens or opportunities associated with these mechanisms. The framework also shows the government's financial burden of supporting these mechanisms. The framework was developed for four levels of refinery capacity. Overall, this framework can be used as a decision support tool by various stakeholders to determine whether to engage in alternative jet biofuel supply chains and negotiate with one another.

Publications

We have provided the tool to the sponsor and will provide training on its use to the project sponsor upon request.

Outreach Efforts

Our tool has been presented and discussed at three ASCENT advisory committee meetings.

Awards

None.

Student Involvement

None.

Period A, Task 1.3.2 - Additional Quantification of Risk and Uncertainties in Supply Chains (Foundational Part of Task 1.3.1)

The Pennsylvania State University

Objective

Develop methods to rely on expert judgments to quantify uncertainties associated with biofuel supply chains.

Research Approach

We developed a new econometric approach to quantify the probability distributions of uncertain quantities, such as yield or demand, when an expert panel provides judgments regarding the most likely values. This approach exploits the well-known theory of generalized least squares in statistics for the context in which historical data are available to calibrate expert judgments or when these data are not available.

Milestones

We have described this method in two manuscripts. In the first manuscript, "[Using Subjective Probability Distributions to Support Supply Chain Decisions for Innovative Agribusiness Products](#)," we developed a two-stage procedure to calibrate expert judgments regarding the distribution of biofuel uncertainties, such as the uncertain yields of new varieties of oilseeds, demand, or selling price. In the first step of the procedure, we calibrated the expert judgments by using historical data. Specifically, we used prior judgments provided by experts and compared them with actual realizations (such as predicted yield versus actual yield) to determine the frequency with which each expert over- or underestimated the uncertainty, e.g., expert 1 underestimated the yield 60% of the time, whereas expert 2 underestimated the yield 90% of the time. In the second manuscript, "[Optimal Aggregation of Individual Judgmental Forecasts to Support Decision Making in a R&D Program](#)," we used this information to determine the optimal approach for aggregating the experts' judgments to determine the mean and standard deviation of the probability distributions. In this manuscript, we developed a new optimization protocol for determining the optimal acreage for growing specific crops by considering the estimated mean and standard deviation, as well as incorporating the variability in these estimates. This manuscript won two awards at a professional conference (INFORMS 2021) in November 2021 and in October 2022.

Major Accomplishments

Theoretical development and a numerical study have demonstrated the promise of this approach.

Publications

Peer-reviewed journal publications

Bansal, S., & Gutierrez, G. J. (2020). Estimating uncertainties using judgmental forecasts with expert heterogeneity. *Operations Research*, 68(2), 363-380. doi: 10.1287/opre.2019.1938

Written reports

Bansal, S., & Wang, T. (2019). Using subjective probability distributions to support supply chain decisions for innovative agribusiness products. Report for the *Federal Aviation Administration*.

<https://s3.wp.wsu.edu/uploads/sites/2479/2021/05/ASCENT-Project-001D-attachment-1.pdf>

Bansal, S., & Gutierrez, G. J. (2021). Optimal aggregation of individual judgmental forecasts to support decision making in a R&D program. Submitted to *Operations Research*.

<https://s3.wp.wsu.edu/uploads/sites/2479/2021/05/ASCENT-Project-001D-attachment-2.pdf>

Outreach Efforts

None.

Awards

2021 Decision Analysis Practice Award - INFORMS, November 2021

2022 Decision Analysis Best Publication Award - INFORMS

Student Involvement

None.

Plans for Next Period

This work is now wrapped up so there are no plans for the next period.

Period A, Task 1.3.3 - Supply Chain Risk Analysis Tools for Farmer Adoption

The Pennsylvania State University

Objectives

Understand farmers' risk preferences over a long duration and how these preferences affect their decisions to grow crops that can support AJF supply chains.

Research Approach

We surveyed farmers to understand their risk preferences over extended durations. Specifically, we presented farmers with sample yield ranges over extended periods and asked them to estimate the lowest equivalent guaranteed yield that they would be willing to accept, given the uncertain yields. We used these responses to perform statistical analyses.

Milestones

We have completed the survey and have written a manuscript based on the survey.

Major Accomplishments

We compiled data from 43 farmers in central Pennsylvania regarding their preferences, given uncertain yields from their land. The results quantify the loss of value that farmers attribute to an uncertain yield. Results are reported for both 1-year and 10-year horizons. For the 10-year horizon, we also report results for an initial yield build-up, which often arises with most biofuel crops. The key takeaways from this study are as follows: (a) farmer valuations of a new crop decrease acutely as the uncertainty in yield increases, and (b) the initial build-up period of low yields can be a large deterrent that inhibits farmers from adopting new crops for the purpose of supporting biofuels.

Publications

A manuscript detailing this work has been written and provided to the sponsor.

Outreach Efforts

None.

Awards

None.

Student Involvement

None.

Plans for Next Period

This work is now wrapped up so there are no plans for the next period.

Period A, Task 1.4.1 - National Survey of Current and Proposed State and Federal Programs that Monetize Ecosystem Services

The Pennsylvania State University

Objectives

Conduct a survey and summarize current and proposed state and federal programs to monetize ecosystem services.

Research Approach

This task builds on and continues the work performed under ASCENT Project 001, Task 8.1, which focused on the biomass and water quality benefits to the Chesapeake Bay watershed. In previous years, we examined the biofuel law and policy landscape of the Pacific Northwest and Southeast regions, as well as the state of Hawaii. During this most recent time period for reporting (October 1, 2021 to September 30, 2022), we focused on federal biofuel law and policy, and how they have been affected by international drivers.

Milestones

Our research was previously circulated in three region-specific white papers. In addition, we developed a federal-level white paper in the list of tasks, which was subsequently published (see below).

Copies of these documents are available online:

- Western U.S. policy manuscript (with a focus on Washington state, last updated in 2019): [Western US Bioenergy Law & Policy - Draft 5.docx](#)
- Southeast policy manuscript (with a focus on Tennessee): [Southeast Bioenergy Law & PolicyDraft3.docx](#)
- Hawaii policy manuscript: [Hawaiian Biofuel Law & Policy_v5.docx](#)
- Federal-level white paper: [2021_01_08_SAF paper draft_circulated for review_KCL_NB \(1\).docx](#)

Major Accomplishments

In addition to developing the white papers described above, we adapted the federal-level white paper for publication (see below). We also provided a briefing and poster during the ASCENT fall meeting (October 2021). Additionally, P.I. Lara Fowler is involved in another project, funded by the USDA National Institute of Food and Agriculture, entitled "Consortium for Cultivating Human and Naturally Regenerative Enterprises" (USDA-NIFA Sustainable Agricultural Systems Award 2020-68012-31824), dubbed the "C-CHANGE" project. She has built upon her work in this ASCENT project to link to the regenerative agriculture work being pursued in C-CHANGE, including providing a briefing on second-generation biofuel law and policy.

Publications

Peer-reviewed journal publications

Korkut, E. & Fowler, L. B. (Nov. 2021). Regulatory and policy analysis of production, development and use of sustainable aviation fuels in the United States." *Frontiers in Energy Research*, 9, 750514. doi:10.3389/fenrg.2021.750514.

Outreach Efforts

Presentations

- Fowler, L. B., & Lewis, K. (October 2021). Sustainable aviation fuel development: Law, policy and the blender's tax credit. Manuscript presented at the ASCENT Annual Meeting.

Awards

None.

Student Involvement

Ekrem Korkut graduated from the Penn State School of International Affairs in May 2021 and transitioned to working as a postdoctoral associate on this project (50% of his time; the other 50% is funded by another project).

Plans for Next Period

As noted above, we will continue adapting the existing white papers for publication. The next step again focuses on regional efforts. As needed, we will provide support to working groups under the sustainable aviation fuel (SAF) Grand Challenge. Of note, work on this task was delayed by the lack of a contract in the 4.5 months from February 1, 2022 to June 14, 2022.

Period A, Task 1.4.3 - Help Support Stakeholder Engagement Efforts

The Pennsylvania State University

Objective

Facilitate dialogue among producers, industry, government, and other affected stakeholders.

Research Approach

Our work under this objective has focused on stakeholder engagement and facilitation of effective dialogue to help bridge gaps among producers, industry, government, and other affected stakeholders. This role supports the needs of other team members.

Milestone

These efforts have supported stakeholder engagement efforts led by other teams, including but not limited to the regional partners identified in ASCENT Project 01, Tasks 3.1, 3.2, and 3.3.

Major Accomplishments

This set of tasks has been relatively limited, and no major accomplishments have been made to date. We have continued to participate in discussions and calls related to potential stakeholder engagement needs.

Publications

None.

Outreach Efforts

None.

Awards

None.

Student Involvement

None.

Plans for Next Period

Future work under this objective will include presenting to the project partners on facilitation skills and tactics. Additional support for regional projects will be offered as needed for facilitation and stakeholder engagement sessions as the regional projects move to the deployment stage. As needed, we will provide support to working groups under the SAF Grand Challenge.

Note: although the proposed contract period was intended to start on February 1, 2022, no contract was in place from February 1, 2022 to June 13, 2022, thus leaving a gap of approximately 4.5 months without funding.

Period B, Task 1- Law and Policy Research

The Pennsylvania State University

Objectives

Understand existing federal law and policy drivers affecting SAF, including participation by the United States in international discussions and agreements (Task 1.1); research existing state law and policy drivers (Task 1.2); research potential law and policy drivers as needed (Task 1.3); and explore other issues identified by the ASCENT 001 team as needed (Task 1.4).

Research Approach

Following up on publication of the *Frontiers in Energy* review of law and policy, we began research on the recently adopted Blender's Tax Credit and the potential Sustainable Skies Act. In addition, we updated our legal and policy research on different states' activities regarding SAF (including CA, OR, WA, and others).



Milestone

We engaged in team meetings and provided updates on legal research topics.

Major Accomplishments

We provided real-time analysis of pending federal legislation (the Inflation Reduction Act) at the request of Project Manager Nate Brown. In addition, we researched and shared information related to pending Securities and Exchange Commission rulemaking on greenhouse-gas-emissions accounting.

Publications

We are exploring possibilities for another formal publication.

Outreach Efforts

Our research has been discussed through several presentations:

- Fowler, L. B., & Korkut, E. (December 2022). ASCENT 001 Team Briefing on pending Securities and Exchange Commission Greenhouse Gas Emission rules.
- Fowler, L. B. (October 2022). Briefing to Volvo Corporation on Opportunities Related to the Renewable Fuel Standard and SAF.
- Fowler, L. B., & Korkut, E. (July 2022). Update on State Legal and Regulatory Opportunities for SAF. ASCENT 001 Project Meeting.
- Fowler, L. B. (June 2022). Legal and Regulatory Drivers of Sustainable Aviation Fuel. Global Council for Science and the Environment.

Awards

None.

Student Involvement

None.

Plans for Next Period

We will continue to work with the ASCENT 001 Team to identify potential law and policy concerns and opportunities. How SAF and renewable natural gas might be developed in synergistic ways is another question that we are exploring.

Period B, Task 2 - Support Stakeholder Engagement Efforts

The Pennsylvania State University

Objective

Facilitate dialogue among producers, industry, government, and other affected stakeholders.

Research Approach

Our work under this objective has focused on stakeholder engagement and facilitation of effective dialogue to help bridge gaps among producers, industry, government, and other affected stakeholders. This role supports the needs of other team members.

Milestone

These efforts have supported stakeholder engagement efforts led by other teams, including but not limited to the regional partners identified in ASCENT Project 001.

Major Accomplishments

This set of tasks has been relatively limited, and no major accomplishments have been made to date. We have continued to participate in discussions and calls related to potential stakeholder engagement needs.

Publications

None.

Outreach Efforts

None.

Awards

None.

Student Involvement

None.

Plans for Next Period

Future work under this objective will include presenting to the project partners on facilitation skills and tactics. Additional support for regional projects will be offered as needed for facilitation and stakeholder engagement sessions as the regional projects move to the deployment stage. As needed, we will provide support to working groups under the SAF Grand Challenge.

Period B, Task 3 - Carbon Capture and Sequestration

The Pennsylvania State University

Objective

Understand how CCS could be integrated with sustainable aviation fuel development.

Research Approach

The new area of research involves a technical focus on integration of CCS with liquid fuel production and examination of soil organic carbon. For this task, Dr. Anne Menefee will focus on the technical viability and sustainability of integrating liquid fuel production with CCS. Her research is broadly focused on decarbonization of the energy sector; she has extensive experience specifically in carbon sequestration. Across scales, her research ranges from exploring fundamental geochemical-geomechanical feedback in stressed fracture systems that are targeted by subsurface sequestration operations to evaluating the system-level environmental impacts of emerging technologies that can both curb net emissions and be self-sustaining in the market. Most relevantly, she has worked on life-cycle and techno-economic assessments of subsurface technologies for carbon sequestration and waste management in the energy sector.

Milestone

This work has recently started.

Major Accomplishments

None.

Publications

None.

Outreach Efforts

None.

Awards

None.

Student Involvement

None.

Plans for Next Period

Because approval for this work was delayed, this work has just started. Additional consultation with the ASCENT 001 Team is needed regarding the proposed and potential next steps. This technical work should support implementation of the SAF Grand Challenge, the International Civil Aviation Organization Committee on Aviation Environmental Protection, and/or both.

Period B, Task 4 - Organic Soil Carbon

The Pennsylvania State University

Objective

Understand how organic soil carbon might be integrated with sustainable aviation fuel development.

Research Approach

This is another new area of research identified by the ASCENT 001 team. As part of the request on this topic, we identified Dr. Armen R. Kemanian to join the ASCENT 001 Team. The research approach for this task will involve identifying critical questions and refining the scope of work (Task 4.1); conducting a literature review (Task 4.2); and drafting a review manuscript analyzing the opportunities to link organic soil carbon and SAF (Task 4.3).

Milestone

This work has recently started. Dr. Kemanian provided an initial presentation of ideas to think about during the August 25, 2022 ASCENT 001 team meeting.

Major Accomplishments

None.

Publications

None.

Outreach Efforts

Presentation, ASCENT 001 Team (August 2022): "Agroecosystem Productivity and Carbon Intensity when Producing Aviation Fuel: Amplifying Opportunities and Taming Trade-offs."

Awards

None.

Student Involvement

None.

Plans for Next Period

Because approval for this work was delayed, this work has just started. Additional consultation with the ASCENT 001 Team is needed regarding the proposed and potential next steps. As with the technical work associated with CCS, this technical work should support implementation of the SAF Grand Challenge, the International Civil Aviation Organization Committee on Aviation Environmental Protection, and/or both.