Project 001(E) Alternative Jet Fuel Supply Chain Analysis

University of Illinois at Urbana-Champaign

Project Lead Investigator

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Other Lead Personnel:
Paul Smith – PSU; Tim Rials – UTK

University Participants

University of Illinois at Urbana-Champaign
P.I.: Jody Endres, Assistant Professor, Natural Resources and Environmental Sciences
- FAA Award Number: 13-C-AJFE-UI, Amendment 002
- Period of Performance: September 1, 2014 to August 31, 2015
    1. Task #6: Risk Assessment in Supply Chains

P.I.: Madhu Khanna, Professor, Agricultural and Consumer Economics and Luis Rodriguez, Associate Professor, Agricultural and Biological Engineering
- FAA Award Number: 13-C-AJFE-UI, Amendment 002
- Period of Performance: September 1, 2014 to August 31, 2015
    1. Task #1: Feedstock Production
    2. Task #2: Feedstock Logistics
    3. Task #6: Risk Assessment in Supply Chains

P.I.: Luis Rodriguez, Associate Professor, Agricultural and Biological Engineering
- FAA Award Number: 13-C-AJFE-UI, Amendment 002
- Period of Performance: September 1, 2014 to August 31, 2015
    1. Task #1: Feedstock Production
    2. Task #2: Feedstock Logistics
    3. Task #6: Risk Assessment in Supply Chains

Project Funding Level

$199,943 FAA funding; $199,943 matching funds (FY 2014-2015)
$100,000 FAA & A4A funding; $100,000 matching funds (FY 2015-2016)

Investigation Team

Task 1: Feedstock Production
Madhu Khanna: P.I. (UIUC)
Luis Rodriguez: P.I. (UIUC)
Tao Lin: Postdoctoral researcher (UIUC)
Fanglin Ye: Graduate student (UIUC)
Zhangliang Chen: Graduate student (UIUC)
Ruiqing Miao: Postdoctoral fellow (UIUC)
Weiwei Wang: Postdoctoral fellow (UIUC)

Task 2: Feedstock Logistics
Luis Rodriguez: P.I. (UIUC)
Tao Lin: Postdoctoral researcher (UIUC)

Task 6: Risk Assessment in Supply Chains
Jody Endres: P.I. (UIUC)
Alison Gomer: Postdoctoral researcher (UIUC)
Katt Gu: Law/Graduate student (UIUC)
Madhu Khanna: P.I. (UIUC)
Luis Rodriguez: P.I. (UIUC)
Tao Lin: Postdoctoral researcher (UIUC)
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Project Overview

Task 1.1 (Lead: Rials; supported by Wolcott, Khanna, Rodriguez) – Assess and inventory feedstock options pursuant to scenarios proposed by the Midwestern Aviation Sustainable Biofuels Initiative (MASBI).

Task 1.2 (Lead: Rials; supported by Wolcott, Khanna) – Delineate the sustainability impacts associated with the feedstock scenarios for the MASBI region, including land use effects.

Task 2.1 (Lead: Volpe and INL; supported by Wolcott, Rodriguez) – Examine the supply chains associated with the MASBI feedstock scenarios to optimize feedstock delivery to biorefineries using logistics and transportation models.

Task 6.1 (Lead: Endres; supported by Smith) – Assess the impact of current laws, policies, incentives and the potential for certification on the development of the US and EU biofuel industries with implications for AJF.

Task 6.3 (Lead: PNNL; supported by Wolcott, Khanna, Rodriguez, Endres) – Conduct supply chain analysis for two regions using a geospatial siting and operational risk assessment tool.

Tasks 1.1, 1.2, 2.1, and 6.3: Feedstock Production and Logistics and Supply Chain Analysis

University of Tennessee, Volpe, INL, and University of Illinois at Urbana-Champaign

Objective(s)

This research effort has two objectives. The first objective is to develop information on regional supply chains for use in creating scenarios of future alternative jet fuel production. Outputs from this project will be used as inputs to a regional supply chain analysis tool being developed by the Volpe Center. The second objective is to identify the key barriers in regional supply chains that must be overcome to meet national targets of 1 billion gallons of alternative jet fuel by 2018 and an order of magnitude larger production in the longer term.

Research Approach

The primary methodology employed here was the compilation of a literature review of previous works performed by the investigators and other investigators outside of Illinois with a focus on biomass-to-bioenergy logistics modeling and techno-economic analysis, with a particular focus on the concerns identified within the MASBI region. Literature was compiled collaboratively by the investigators and the students and post-doctoral researchers collaborating on this project.

The MASBI region has several major airports, but the four largest are those in Chicago, St. Louis, Indianapolis and Detroit. Feedstocks to produce alternative jet fuel for these airports are currently expected to be supplied from the states where these airports are located or in adjoining states. We, therefore, define the MASBI region as consisting of seven states, IL, IA, IN, MO, KY, OH, and MI in the Midwestern region of the US. The feedstocks we are considering in this analysis are perennial energy crops (miscanthus and switchgrass) and corn residues, which can be grown under a wide range of growing conditions in the eastern half of the US, under rain-fed conditions.

The major components of a biomass supply chain are feedstock production by farmers, transportation and location of centralized storage facilities that can supply biomass to meet the year-round demand of refineries, location of the biorefineries, transportation of biomass to the refinery and distribution of the biofuel from the refinery to the airport. The development of a biomass supply chain needs to incorporate the explicit spatial distribution of production and its low physical density and energy density (per unit volume). Additionally, feedstocks are typically harvested annually, during fairly limited harvesting windows and then stored for meeting year round demand at refineries. Thus, the design and operation of biomass supply chain systems significantly depends on spatial and temporal constraints of supply such as feedstock type and yield, geographical location and siting, and land availability.

Feedstock production by farmers involves deciding whether or not to produce a feedstock and if so to select the specific feedstock to produce; these decisions could involve changes in the use of land from existing crops to new crops. Farmers face several options for methods of feedstock production, storage and delivery. Faced with a given price of biomass, they can be expected to seek least cost methods by selecting appropriate equipment, storage and delivery methods. Optimization of the entire supply chain also involves designing and locating centralized storage facilities to balance cost, storage losses, and transportation costs. Additionally, biorefinery location and capacity need to be selected to balance economies of scale with larger production capacity with higher costs of transporting low density, high volume, feedstock from a longer distance. The location of the biorefinery relative to feedstock producers, blending facilities and final users also needs to be based on considerations of the mode (rail versus road) of feedstock transportation and form (whether baled, chopped or densified) of feedstock as well as the mode of transporting the biofuel (trucks versus pipeline) from the refinery to the airport.

Given the nature of agricultural commodity supply and demand, the design of a biomass-biofuel supply chain can initially be modeled after existing grain-food systems (Figure 1). In a typical grain-food system in the U.S., grain is hauled by trucks from fields to grain elevators and centralized facilities for better access to transportation networks. The processed agricultural products are then transported to centralized food production facilities and distribution centers by trucks and rail cars. Similar to grain-food supply chain systems, a typical biomass-biofuel supply chain having many suppliers and few processing facilities can be designed to gain economies of scale (Lin et al., 2015a).

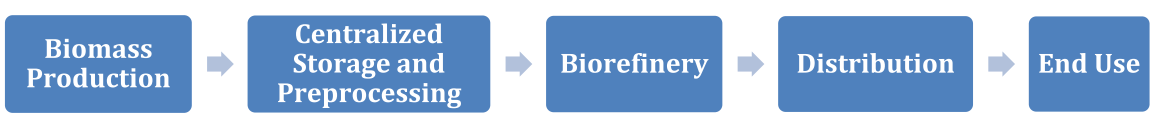

Figure 1. The scope of a biofuel supply chain system

Our primary goal in this project has been the development of a whitepaper overviewing the primary challenges, opportunities, and data sources for analysis of biomasss-to-bioenergy supply chains within the MASBI region.

Milestone(s)

Doctors Khanna and Rodriguez presented an overview of biomass-to-bioenergy concerns within the MASBI region at the Spring Meeting in Alexandria, Virginia.

Major Accomplishments

A white paper was submitted to FAA on August 3, 2015.

Publications
Written report: Alternative Jet Fuel Supply Chain Analysis in the MASBI Region

Outreach Efforts
Doctors Khanna and Rodriguez presented an overview of biomass-to-bioenergy concerns within the MASBI region at the Spring Meeting in Alexandria, Virginia.

Awards
None

Student Involvement
- Dr. Tao Lin currently continues to work at Illinois, but has been offered a faculty position at the University of Puerto Rico-Mayagüez.
- Zhangliang Chen is a current and on-going graduate student who helped with the literature review.
- Fanglin Ye is a current and ongoing graduate student who helped to compile the data.
- Ruqiing Miao and Weiwei Wang are post-doctoral fellows who helped with the economic analysis underlying the supply curves for biomass under various assumptions about risk preferences of farmers.
- Ruiqing Miao now has a faculty position at Auburn University.
- Weiwei Wang is continuing as a post-doc at Illinois.

Plans for Next Period
The aviation sector consumes 20 billion gallons of jet fuel each year and is responsible for 2% of global carbon dioxide emissions. Demand for aviation is expected to increase significantly in the near to medium term. Growing concerns about climate change and the rising cost of fuel have led to interest in alternative jet fuel from renewable sources. The purpose of this research project is to analyze the economic and engineering design issues in establishing a supply chain for jet fuel production in the MASBI region.

Our analysis will consider two feedstocks for which data is available in the MASBI region from the POLYSYS model: corn stover and switchgrass. POLYSYS data will be integrated with our previously developed analytical tools, which will subsequently be upgraded and adapted for application to the MASBI region. We will then examine the on-farm costs of production taking into account operational decisions about optimal equipment sets based on farm size, biomass yield, biomass quantity demanded, and the location. We will examine feedstock choices given feedstock yields, costs of production, and land availability. We will also examine the logistical requirements for storing, preprocessing, and transporting biomass to conversion facilities and for delivering fuel to pipelines and other major airports in the Midwest.

Work outlined for Year Two will focus first on the Indianapolis Airport, but work will be designed for expanded consideration of other parts of the MASBI region in subsequent years. The analysis will be used to determine the location of feedstock supply regions, optimal size and type of farm equipment and field processes, on-farm storage selection and sizing, location and size of centralized storage, preprocessing, and transportation fleet size and scheduling to meet the demand for jet fuel at a regional airport at least cost. Our analytical framework is geographical information system based and will consider existing infrastructure such as roads, highways, railways, location and capacity of existing blending facilities and refineries, and the oil pipeline network. Other constraints to biomass transport and delivery such as road congestion, density of biomass and the costs of long-term storage with annual harvests will be examined.

Task 6.1: Assessment of impact of current laws, policies, and incentives, and potential for certification on the development of the US and EU biofuel industries with implications for AJF
University of Illinois at Urbana-Champaign, The Pennsylvania State University

Objective(s)
- Identify policy barriers and gaps to successful commercialization of alternative jet fuel (AJF) in the US and European Union (EU).

- Propose model frameworks and strategies to overcome obstacles through policy design.
- Specifically, examine policy design that enables the AJF supply chain to be considered "sustainable" by the public, supply chain suppliers and consumers, and regulators in the US and internationally.
- Determine how a potential Product Category Rule (PCR)/Environmental Product Declaration (EPD) can be a vehicle for ASCENT's work to further sustainability within the aviation sector.

Research Approach

The primary methodology employed here was a literature review with a focus on sustainability accounting, specifically PCR/EPD development. Literature was compiled collaboratively by the investigators, and post-doctoral and graduate student researchers, collaborating on this project.

Due to climate change concerns, policymakers are keen to displace conventional, carbon-based fuels with more environmentally-friendly alternatives. While previous policy incentives have focused on ground-based transportation fuels, jet fuels provide a more certain demand pathway because the sector cannot choose to use electricity-based power like ground-based transportation can. The FAA, as well as other federal agencies such as the Departments of Energy, Agriculture, and Defense, therefore are pursuing an active research agenda to achieve 20 billion gallons of alternative jet fuel in the nation's fuel supply by 2025. Civil society groups, however, are skeptical of claims that bio-based fuels can do any better from a sustainability performance perspective than their conventional fuels counterparts. Thus, it is imperative for bio-based industries, such as the jet fuel sector, to develop quantitative metrics for performance indicators and a way in which to communicate sustainability impacts to the public and policymakers. Indeed, all product supply chains face the same challenge from civil society groups—that sustainability claims are quantified and verified.

In response to questions presented by the FAA regarding the possibility of PCRs and EPDs for AJF, the research specifically focused on examining International Organization for Standardization (ISO) rules for PCRs/EDPs, and the PCR bases of the hundreds of EPDs internationally. Specifically, this approach enabled us to understand how different PCR efforts have categorized and addressed environmental impacts, including GHG accounting, water and soil quality, air pollution, and biodiversity. Researchers actively participated in methodology building efforts nationwide (including larger ASCENT team efforts within ASCENT 001) to discern methodologies and datasets that could be used in developing PCRs. The project team has observed, albeit from a distance at this point, the carbon accounting methodology building by the MIT-Purdue team. We know understand how to build, using the ISO 13025 framework, an accounting system for the aviation sector that measures the sustainability impacts from farm-to-fleet through the PCR, and how to communicate these impacts through the EPD. Sustainability impacts include GHG emissions (including indirect land use change), biodiversity loss, decreased water quality and quantity, and socio-economics (including but not limited to community development such as job creation, and compliance with labor and employment law).

The PCR accounting system provides much needed clarity and transparency as to the methodologies used to measure sustainability, thus increasing public awareness of the scientifically-substantiated sustainability attributes of bio-based fuels. In turn, public awareness leads to legitimacy of a sustainability claim, even if it merely declares versus compares to a baseline. In addition, PCR development can better facilitate sustainability labels across jurisdictions by providing a foundation of common understanding of methodologies. Measurements are based on lifecycle analysis (LCA) where possible, developed according to generally accepted practices, and are communicated to the public in a standardized way. Further, where LCA methodologies do not exist, the PCR requires explanation of what methodologies are applied, which is particularly important in the socio-economic sustainability realm. The transparent nature of the PCR process also identifies where uncertainties lie, adding critical clarity to public debates that fester because those involved are not (capable of) acknowledging how uncertainty is being treated in their positions. The sometimes speculative nature of civil society groups' claims have hurt unnecessarily the ability of the sector to commercialize. However, FAA leadership, coupled with new support from DOE, will enable university-based facilitation and science to either validate or refute those claims. The research community has generated a proliferation of measurement methodologies; however, this work has not translated effectively into public and policy discourse on the sustainability of alternative fuels. PCR development will address that shortcoming.

Milestone(s)

A draft white paper will be completed in October 2015 and will be shared with FAA and A4A to further facilitate discussion on how to proceed with a PCR process and field testing within the DOE multifunctional landscapes project in 2015-2016.

Major Accomplishments

The accomplishments of this task (Task 6.1 will provide the project and stakeholders a clear vision of how to develop a PCR for the sustainability of AJF in the U.S. This PCR will be world-leading, as no group, governmental or otherwise, has ever completed such a methodology-gathering exercise.

Publications

PI Jody Endres (UIllinois):

- Evelyne Thiffault, **Jody Endres**, James McCubbins, Martin Junginger, Miren Lorente, Uwe Fritche, Leire Iarte (2015). *Sustainability of forest bioenergy feedstock supply chains: Local, national and international policy perspectives*. Biofuels, Bioproducts & Biorefining DOI: 10.1002/bbb (2015)
- Jody M. Endres & Matthew A. Walker, *A Tale of Three Watersheds: U.S. EPA's Contrasting Approaches to Agricultural Nutrient Pollution*, 2 WIRE'S Water 47-54 (2015)
- Jody M. Endres, Rocio Diaz-Chavez, Stephen R. Kaffka, Luc Pelkmans, Joaquim E.A. Seabra, Arnaldo Walter. *Sustainability Certification for Biomass Applications: Opportunities for Generating New Science*, in Bioenergy & Sustainability: Bridging the Gaps (U.N. SCOPES Rapid Assessment Project) (2015)

PI Paul Smith (PSU):

- Dahmann, K.K.S., L.B. Fowler, and P.M. Smith. 2016. United States Law and Policy and the Biofuel Industry; included in a Volume on "*The Law and Policy of Biofuels*" co-editors, Yves Le Bouthillier, Annette Cowie, Paul Martin and Heather McLeod-Kilmurray, Edward Elgar Publishing, as part of the IUCN Academy Series. *Submitted June 30, 2014. Accepted and in press.*

Outreach Efforts

PI Jody Endres (UIllinois):

- Jody M. Endres, *Designing Governance Systems to Solve Nutrient Pollution: Lessons from Clean Water Act Litigation*, University of Illinois Institute for Energy and Environment Water Congress (Sep. 2015).
- Jody M. Endres, *Illinois Water Law Under Conditions of Uncertainty*, Joint Meeting of the Chicago Energy Bar Association and Association of Energy Economists (Apr. 2015)
- Jody M. Endres, *The Prospects of Product Category Rules and Environmental Product Declarations for the Biojet Sector*, Federal Aviation Administration ASCENT Bi-Annual Meeting (Mar. 2015)

Awards

None

Student Involvement

Zihui (Katt) Gu is a law/graduate student and Chinese national who continues to be involved in this project. Her work involves research on PCR/EPD development, and specifically difference governance approaches. This is particularly important, as ISO standards and ISEAL governance standards must be considered in building the PCR. PI Endres is hopeful that Katt will also have the opportunity to participate in RSB certification efforts in China. While we have taken a US-EU centric approach in this project, it behooves us to begin understanding of the Chinese approach because they are increasingly expressing interest in biojet projects (e.g., the recent NRDC-Boeing-China project announcement). We do not want to be caught flat-footed with regard to our PCR design at least to the extent that we should understand China's preliminary thinking with regard to quantification approaches.

Alison Gomer, J.D. is postdoctoral researcher who continues to be involved in this project with regard to research on PCR/EPD development. Specifically, she is tasked with dissecting all existing PCRs for the approaches they take, and has been the lead in analyzing recently issued USEPA guidance on PCR building.

Plans for Next Period

The University of Illinois will moderate the process of building a PCR for Bio-based jet fuel, including development of indicator categories and measurement methodologies, developing a draft PCR, convening stakeholder consultation group(s) and incorporating their comments into the draft, and completing a final PCR for deposit into a PCR repository.

PI Endres was awarded in September 2015, along with her project partners, $9 million by the DOE to study, among other items, how to operationalize sustainability verification for three of the country's premier biorefinery projects: Poet-DSM and Dupont/Pioneer in Iowa, and Abengoa in Kansas. Similar to the goals of FAA and A4A, DOE expects the investigation to include application of RSB standards, among others (e.g., ATIP/ASABE, TSC/FTM) to the project. Thus, an excellent opportunity exists to develop synergies between ASCENT and the DOE project with regard to isolating and field-testing methodologies that would go into a PCR. The DOE project also provides a natural governance platform from which to work in stakeholder collaboration, as all of the most knowledgeable and powerful stakeholders in the U.S. are involved in the project, at least from a cellulosic fuels perspective. RSB has received funding from the DOE to separately reach out to growers in the U.S., including growers not included in the DOE multi-functional landscapes project such as camalina and other oilseed growers in the northwestern U.S. PI-Endres is likely to be leading that outreach, but the details have yet to be finalized. Optimally, that outreach would occur in conjunction with the DOE project, as well as FTM pilot study sites.

PI Endres would like to further consider with the ASCENT funders whether or not a PCR should go beyond agricultural-based feedstocks to include those from forestry. She has IEA funding for a case study on short-rotation woody biomass used for pellets exported to Europe, which could serve as a platform for examining the Sustainable Biomass Partnership Certification in relation to their methodologies. Their approach could be compared to that of FSC, which is recognized by RSB, and which has a certification in the NARA project area.

PI Endres will be a participant in 2015-2016 building the American Society of Agronomy's (ASA) training program for certified crop advisors in the U.S. The effort involves building a curriculum for online study and testing of sustainability principles, ranging from policy matters through technical aspects of sustainability accounting. All of the major commodity groups are involved in the program. Not only can the FAA/DOE work translate into that curriculum in terms of identifying capacity needs in sustainability certification, but the ASA's work could be a proxy for the outreach necessary to growers for understanding accounting and their participation in the certification process.

Depending on PSU's funding and amenability to cooperation, PI Endres would like to incorporate PI-Smith's program of study in Task 5.1 into the DOE project. Although PI-Endres' work has focused on accounting within agricultural landscapes, identifying biorefinery-side barriers constitute an important element of sustainability certification in many ways as well.