Project 001(A) Alternative Jet Fuel Supply Chain Analysis

Washington State University

Project Lead Investigator

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University Participants

Washington State University

- P.I.(s): Michael P. Wolcott, Regents Professor; Michael Gaffney, Director, DGSS; Manuel Garcia-Perez, Associate Professor; and Xiao Zhang, Associate Professor
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- Task(s):
    - WSU 1. Design cases– Garcia-Perez, Zhang
    - WSU 2. Evaluation of the most promising bio-refinery concepts for AJF production. Garcia-Perez, Zhang
    - WSU 3. Supplement and maintain the current inventory of bio-refinery infrastructure identified in the conversion design cases that are useful for production of AJF Wolcott
    - WSU 4. Community Social Asset Assessment Gaffney
    - WSU.5 Refine and deploy the facility siting tools for determining regional demand and potential conversion sites to be used in regional analyses. Wolcott
    - WSU.6 Refinery to Wing Stakeholder Assessment. Gaffney
    - WSU.7 Supply Chain analysis. Wolcott-Garcia-Perez
    - WSU. 8 Analytical support for regional CAAFI and USDA jet fuel project. Wolcott

Project Funding Level

$274,999 FAA funding and $274,999 matching funds. Source of matching funds are $270,000 Washington State University salary contributions.

Investigation Team

- Michael Wolcott, Project Director/Principal Investigator
- Michael Gaffney, Co-Project Director/Co-Principal Investigator
- Manuel Garcia-Perez, Co-project Director/Co-Principal Investigator
- Paul Smith, Faculty
- Season Hoard, Faculty
- John Snyder, Faculty
- Kristin Brandt, Staff Engineer
- Natalie Martinkus, Staff Engineer
- Sarah Dossey, Staff Engineer
- Postdoctoral (100 %)
- Dane Carmenzid, Graduate Student
- Lina Pilar Martinez Valencia, Graduate Student

- Tanzil Abid Hossain, Graduate Student
- Daniel Mueller, Graduate Student

Collaborating Researchers

- Burton English, University of Tennessee
- Kristin C. Lewis, Volpe

Project Overview

As part of an effort to realize an "aviation system in which air traffic will move safely, swiftly efficiently, and seamlessly around the globe", the Federal Aviation Administration (FAA) has set a series of goals and supporting outcomes, strategies, and performance metrics (Hileman et al 2013). The goal entitled, "Sustaining our Future" outlines a number of strategies that are collectively aimed at reducing the environmental and energy impacts of the aviation system. To achieve this goal, the FAA set an aspirational goal of aviation utilizing 1 billion gallons of AJF by the year 2018. This goal was created from an economic, emissions, and overall feasibility perspective (Richard 2010, Staples et al. 2014).

Current approaches to supply chain analysis for AJF optimizes transportation logistics of feedstocks to refinery and refinery to wing (Bond et al 2014). One of the largest barriers to large scale production of all bio-fuels is the high capital cost of greenfield facilities translating to risk in the investment community (Huber et al 2007). The capital cost of cellulosic ethanol plants range from $ 10-13/gal capacity (Hileman and Stratton, 2014). The additional process steps required to convert the intermediate to a drop in AJF could increase this cost to over $ 25/gal capacity (Hileman 2014).

The realities of these initial commercialization efforts into second-generation biofuel have led to studies that envision alternate conversion scenarios including transitioning existing facilities (Brown 2013). Gevo is employing retrofit strategies of corn ethanol plants for producing isobuthanol, a potential intermediate for the alcohol-to-jet process of producing iso-paraffinic kerosene (Pearlson 2011, Pearlson et al 2013). Research to envision scenarios to achieve the FAA aspirational goal of AJF consumption relied upon "switching" scenarios where existing and planned capacity would be used for producing the drop-in fuel (Malina et al 2012). All of these approaches require identifying existing industrial assets to target for future AJF production. Siting becomes, not just an exercise of optimizing feedstock transportation, but aligning this critical factor with a host of existing infrastructure, markets within regions with the proper social capital for developing this new industry (Seber et al 2014, Henrich et al 2007).

Up to now all the AJF supply chain analyses published have been limited to standalone jet fuel production technologies that do not generate bio-products. The potential techno-economic and environmental benefits of using existing industrial infrastructure and the production of co-product on the development of jet fuel production scenarios has to be considered in future studies.

This project is part of a series of activities to evaluate regional jet fuel supply chains and to estimate the potential of the U.S. to produce alternative jet fuels. In previous years we created the tools to conduct such analyses. At WSU several design cases for alternative jet fuels (Alcohol to Het (ATJ), Hydrotreated Depolymerizes Cellulosic Jet (HDCJ), Direct Sugars to Hydrocarbons (DSHC), Synthetic kerosene and Synthetic Aromatic Kerosene (SK&SAK), Catalytic Hydrothermolysis (CH) and Synthesized Kerosene-containing Aromatics (FT-SKA) and some of the technologies forming our infrastructure (pulp and paper mills, sugarcane mills, dry corn ethanol plants, petroleum refineries) were created as well as data bases of the existing infrastructure. This information is being used in supply chain analyses. Our goal is to identify supply chains that could allow U.S. achieve alternative jet fuels production as close as possible to its potential. The technical results obtained by the regional teams will be analyzed in conjunction with the studies on social attitudes to create recommendations on how we best catalyze the creation of jet fuel supply chains.

Task WSU 1. Design cases

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Objective(s)

Continue refining and improving the design cases developed for six standalone alternative jet fuel (AJF) production technologies (Alcohol to Jet (ATJ), Hydrotreated Depolymerized Cellulosic Jet (HDCJ), Direct Sugars to Hydrocarbons (DSHC), Synthetic kerosene and Synthetic Aromatic Kerosene (SK&SAK), Catalytic Hydrothermolysis (CH) and Synthesized Kerosene-containing Aromatics (FT-SKA) and existing infrastructure (sugarcane, pulp and paper, corn ethanol and petroleum refineries) that could help with the growth of this industry;

Research Approach

Background: The design cases developed for AJFs and for existing industrial infrastructure, are being used in the development of supply chains and on the identification of synergisms that could eventually lead to the construction of integrated systems of AJF production that take advantage of the infrastructure in a given region. Analysis of the location of existing infrastructure showed that the United States can be divided in regions dominant biomass of the region. So, we believe that a viable approach to evaluate the synergism between the AJF pathways, the existing infrastructure and the co-products is to generate advanced bio-refinery concepts around the Petroleum Refineries Pulp and Paper Mills Sugar Cane Mills, Corn Ethanol Mills and to compare the biorefinery concepts developed for each of these technologies to decide the most promising ones. The most promising bio-refinery concepts for the synergistic production of AJFs and co-products with these industries will then be used in the supply chain analyses.

Standalone design case reports are generated by conducting reviews of research related to each in academic literature and public information available from commercial interests developing the technology. The reports are meant to detail the processes involved in each conversion pathway and outline the technology readiness and particular barriers to implementation. Publically available information on the commercial processes and research literature will provide the foundation of information later used in modeling efforts. Where detailed process engineering information is lacking, new models will be built to estimate the parameters needed to complete assessments such as techno-economic modeling, lifecycle analysis, and supply chain modeling. Aspen Plus is primarily used to generate process models and details including mass balances, energy balances, energy requirements, and equipment size and cost. These results will also aim to provide the basis for comparative analysis between design cases, identifying key advantages and markets for each technology.

Each design case will have the following components: (1) Feedstock requirement (Availability and feedstock composition) (2) Flow diagram of technology (3) Companies commercializing the technology (level of maturity) (4) Current location of units in the United States (In case of an existing technology it will be the inventory of units that could be retrofitted) (5) Literature review on papers reporting data relevant to the operation of the technology (operating conditions, type of reactor used, catalysts, yield of products) (6) Properties of Jet fuel produced (7) Identification of potential intermediates (bio-oil, sugars, densified feedstock); current and potential uses of wastes and effluents; and co-products (biochemicals, carbon, etc.) that can be obtained from the technology

We continued refining the design cases developed for six standalone AJF technologies (Alcohol to Jet (ATJ), Hydrotreated Depolymerized Cellulosic Jet (HDCJ), Direct Sugars to Hydrocarbons (DSHC), Synthetic kerosene and Synthetic Aromatic Kerosene (SK&SAK), Catalytic Hydrothermolysis (CH) and Synthesized Kerosene-containing Aromatics (FT-SKA) and for four important industries (sugarcane, pulp and paper, corn ethanol and petroleum refineries). We received the comments from internal reviewers, and from most industrial reviewers, we are now addressing the comments and recommendations received. Our plan is to submit the final report in the summer 2017. This year we will start developing the design cases for targeted co-products that could improve the economic viability of AJFs. Because lignin utilization alternatives is a problem for all the AJF production concepts using biochemical pathways, we propose to build design cases (a literature review, mass and energy balances and technoeconomic analyses) for three lignin utilization strategies (1) Oxidative depolymerization of biorefinery lignin to valuable chemicals (phenolics and dicarboxylates) (2) Modification of biorefinery lignin for additive and adhesive applications and (3) Synthesize renewable materials from biorefinery lignin.

Responsible: Manuel Garcia-Perez, Xiao Zhang and Michael Wolcott

Milestone(s)

Literature search complete for all pathways and design cases. Draft design cases complete for all pathways and design cases. Internal reports reviewed by team members and external reviewers. We are currently updating the design cases and addressing the comments received from the reviewers.

We are currently building the design cases for targeted co-products from lignin.

Major Accomplishments

Models were developed for the main AJF production technologies and for relevant technologies that can be used as baseline for the synthesis of bio-refinery concepts. The methodology for these models are providing data to form a baseline for comparative analysis with other design cases. Key process variations have been identified in several design cases and have been modeled to determine their effects on process economics and viability, as well as to identify the key barrier toward commercialization in complete biorefinery concepts.

Data generated from the design cases were also supplied to A01 partners to assist with supply chain, lifecycle analysis, and techno-economic models by improving the conversion and cost figures database values. Evaluations of the effects of process variations on the chemical properties of products generated are being used to provide insight into the challenges that will be faced when blending that the AJFs into commercial jet fuel.

Most of the design cases have been reviewed by external reviewers and we are currently addressing their comments and updating the final reports.

Publications

None - Task in Progress

Outreach Efforts

None – Task in Progress

Awards

None – Task in Progress

Student Involvement

Several graduate (Scott Geleynse, Mond Guo, Carlos Alvarez Vasco, Ruoshui Ma, Jonathan Pulgarin-Leon and Tanzil Hossain) and undergraduate students participated in the creation, editing and updating of the design cases for standalone AJF technologies, for relevant existing infrastructure and for co-products from lignin.

Plans for Next Period

Publication of design cases for standalone AJF production technologies and for relevant infrastructure. Complete the first draft design case for co-products from lignin

Task WSU 2. Evaluation of the most promising bio-refinery concepts for AJF production

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Objective(s)

Evaluation of most promising bio-refinery concepts for AJF production. Evaluation of co-products opportunities and synergisms of AJF pathways with existing infrastructure to overcome some of the barriers to produce 1 billion gallons of alternative jet fuel by 2018. Use design cases of existing infrastructure, AJF production technology and co-products identified

to generate new bio-refinery concepts for Petroleum Refineries, Pulp and Paper Mills, Sugarcane Mills and dry corn mills. Use technoeconomic and life cycle assessment to identify the most promising bio-refinery concepts that could be implemented as part of the supply chain analysis. Understand the major technical gaps towards commercialization of each of the bio-refinery concepts proposed.

Research Approach

Background: In this task we are using the design cases of existing infrastructure, AJF production technology and co-products identified to generate new bio-refinery concepts for Petroleum Refineries, Pulp and Paper Mills, Sugarcane Mills and dry corn mills. Each of the bio-refinery concepts proposed is being evaluated. The results from this effort will allow us to identify and select the most commercially feasible bio-refinery concepts. Major technical gaps/barriers toward commercialization of each of the bio-refinery concepts will also be revealed from the results of this study.

Integration of process technologies through a similar approach to the standalone design cases is assessed. Further evaluation of integration concepts will be developed by pairing standalone cases with these opportunities to evaluate the economic and environmental advantage of the integration approaches. During this period we conducted detailed analyses of alcohol to jet conversion (ATJ) and integration with pulp mill operations. We have also investigated the potential of lignin co-products contribution to the overall process economy.

A dry grind corn ethanol mill (DGCEM) with a capacity of 80 million gallons of ethanol per year (MGY) was studied in order to evaluate potential biorefinery scenarios for AJF production. Five alternative jet fuel (AJF) technologies were studied: Virent's BioForming, alcohol to jet (ATJ), direct sugar hydrocarbon (DSHC), fast pyrolysis (FP) and Fischer-Tropsch (FT). A standardized methodology was adopted to evaluate twelve integration scenarios between DGCEM and AJF technologies in terms of minimum fuel selling price (MFSP) and greenhouse gas (GHG) emission. The total alternative jet fuel production capacity ranged from 25 MGY to 50 MGY. Eight scenarios resulted in cost reduction opportunities in capital expenditure (CAPEX) and operational expenditure (OPEX) leading to reduced MFSPs in the range of 6% to 29%. Four scenarios resulted in negative GHG emission. A performance evaluation revealed that integration scenario of fast pyrolysis provided the better results in cost and GHG emission reduction. We are currently conducting similar analyses for a Corn ethanol plant and petroleum refineries.

Major Accomplishments

Economic models and Life Cycle Assessments were used to support the selection of the most promising bio-refinery concepts that make use of our existing infrastructure for AJF production. Modeling project have been underway for the Pulp and Paper and Corn Ethanol integration cases and have been applied to evaluate integration potential, particularly with the Alcohol to Het design one. These efforts are leading to two publications on integration strategies (Pulp and Paper, Corn Ethanol) currently in progress.

Publications

Three publications are in Progress:

(1) Evaluation of the Alcohol to Jet Process
(2) Pulp and paper Integration Strategies for AJF Production
(3) Corn Ethanol Mill Integration Strategies for AJF Production

Outreach Efforts

Pulp Mill Process Integration and Repurposing for Bio-catalytic Alcohol to Jet Fuel Production" Senthil Subramaniam,252nd American Chemical Society, August 20-25, 2016, Philadelphia
Evaluation of Alcohol-to-Jet (ATJ) Conversion Technology for Renewable Jet Fuel, Scott Geleynse at the 2016 Annual Meeting for the American Institute of Chemical Engineers in San Francisco. November 16, 2016
Integration of Renewable Jet Fuel Production with the Pulp Industry through Alcohol Conversion, Scott Geleynse at the 2016 Annual Meeting for the American Institute of Chemical Engineers in San Francisco. November 17, 2016
Techno-Economic Modeling of Lignin to Vanillic Acid Production, Kitana Kaiphanliam at the 2016 Annual Meeting for the American Institute of Chemical Engineers in San Francisco. November 17, 2016

Alternative Jet Fuel Production in Integrated Biorefineries Using Existing Dry Corn Mill: Cost Reduction Opportunities. Abid Hossain Tanzil, Manuel Garcia-Perez, Xiao Zhang, Michael Wolcott.

Awards

None

Student Involvement

Graduate students Scott Geleynse, Senthil Subramaniam, Mond Guo, Carlos Alvarez-Vaso, Abid Tanzil Houssain, Lina Martinez Valencia and Ruoshui Ma have received trained working in this project. An undergraduate student, Kitana Kaiphanliam, funded under an NSF REU grant assisted with building techno-economic models for co-products production scenarios.

Plans for Next Period

Next period Dr. Garcia-Perez's team will focus on the potential cost reductions if alternative jet fuels are integrated with a petroleum refinery and a sugarcane mill. Further work into developing design cases will focus on new technologies and the integration of co-products into biorefinery concepts. Hydrothermal liquefaction, a thermochemical conversion process under significant research at Pacific Northwest National Laboratory, has been identified as a new technology potentially nearing commercial readiness and should be evaluated as a standalone design case. Co-products are alternative chemical products that can be produced alongside AJF that provide additional value in other markets or as a higher-priced commodity. Development of co-product strategies can change the economic outlook for conversion pathways by improving process economics and thus reducing the minimum fuel selling price. As with integration with existing infrastructure, co-product integration is likely a necessary component particularly of early projects which do not follow "nth plant" economics.

Task WSU 3. Supplement and Maintain the Current Inventory of Biorefinery Infrastructure Identified in the Conversion Design Cases that are useful for Production of AJF.

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Objective(s)

Specifically, this task requires annual evaluation of the database to add or eliminate new and close facilities in each category so that the geospatially specific assets are current with reality.

Research Approach

Background: Utilizing existing infrastructure assets is key to retrofit approaches to developing the industry. But to differentiate between the relative value of different options, the specific assets must be valued with respect to their potential use within a conversion pathway. Regional databases of industrial assets that might be utilized by a developing AJF industry, have been assessed on a national level. These baseline databases are compiled from a variety of sources that include industry associations, universities, and news outlets. These databases will be expanded, refined, and validated as the conversion design cases articulate additional needs for the regional analyses.

Milestone(s)

National databases are compiled, geolocated, validated and shared for biodiesel, corn ethanol, energy pellet, pulp & paper, and sugar mill production. We are evaluating the database to add or eliminate new and closed facilities in each category so that the geospatially specific assets are current with reality.

A regional supply chain analysis was completed for eastern Washington and western Montana using forest harvest residuals as the feedstock. This analysis included market fuel demand, potential siting assets and feedstock availability. A siting tool was developed to help determine if the most economical site was a greenfield, co-location or conversion of an existing facility. This tool includes the impact of operating costs including electricity rate, natural gas rate and delivered feedstock cost. Capital costs are included by applying a factored approach to estimating capital costs and accounts for infrastructure

that would be included at an existing facility such as service facilities, equipment costs, buildings and yard improvements. The siting tool combines the operating and capital cost components in a cost-weighted equation. The results of the equation allow for quantitative comparison of multiple locations based on both operating and capital costs.

Major Accomplishments

The national databases have been compiled, validated, and shared with the A01 teams. All of the metadata is complete for use in the regional analyses

Publications

None – these are shared assets for later analyses

Outreach Efforts

Wolcott, M., Martinkus, N., Brandt, K., Garcia-Perez, M., Zhang, X. *Alternative Jet Fuel Supply Chain Analysis ASCENT 1: Northwest Supply Chains. Aviation Sustainability Center (ASCENT) Meeting,* April, Washington D.C.
Wolcott, M., Lewis, K., Brandt, K., Camenzind, D., Martinkus, N., Dossey, S. *Analysis of 2030 Jet Fuel Demand and Supply Chain Assets of Multiple Biojet Feedstocks* [poster]. Aviation Sustainability Center (ASCENT) Meeting, September, Washington D.C.

Awards

None – these are shared assets for later analyses

Student Involvement

Dane Camenzind, Master's student in Civil Engineering, validated the operating status of previously identified production facilities, compiled and geolocated MSW incinerators and landfill gas to energy facilities and worked to assemble and update all county level feedstock information.
Natalie Martinkus, pH.D. candidate in Civil Engineering (degree completed), developed the siting decision matrix as a portion of her dissertation.

Plans for Next Period

Additional refinements will be completed for the siting tool. GIS analysis will be completed after tool is finalized.We plan to continue the annual evaluation of the database to add or eliminate new and close facilities in each category so that the geospatially specific assets are current with reality.

Task WSU 4. Continue work on social asset decision tools developed in Phase 1 for plant siting (Community Asset & Attribute Model—CAAM) through additional statistical testing and case study validation. Extend application to full NARA region and another US region (e.g. MASBI or Chesapeake). Prepare for extension nationally & replication for select EU countries.

Washington State University

Objective(s)

Continue work on social asset decision tools developed in Phase 1 for plant siting (Community Asset & Attribute Model—CAAM) through additional statistical testing and case study validation. Extend application to full NARA region and another US region (MASBI). Prepare for extension nationally & replication for Canada, and select EU countries.

Research Approach

Based on key measures of collective action, creativity, and health, WSU has developed and refined a Community Asset and Attribute Model (CAAM). This quantitative tool was initially applied to the NARA region. It will subsequently be refined, re-weighted, re-calibrated, and applied to the US Midwest region and then made available nationally. Social Assets, the weighted measures of a community's capacity for collective action and adaptation to change, have been aggregated at the county level for the entire US. These measures have been used to assess social capacity for biorefinery siting, and were recently combined with biogeophysical analysis to identify former paper mill facilities that could most effectively be retrofitted to support a biorefinery in the Pacific Northwest.. Social capacity measures include indicators of social capital, creative leadership, and human capital, which are currently being validated through ground-truthing analysis to assess their role in the success or failure of biofuel related projects in both the NARA and BANNER regions.

Milestone(s)

The validated CAAM model based on county-level comparative rankings on Social, Human and Cultural Capitals is tested and available for use.

Major Accomplishments

The refined CAAM model has been combined with biogeophysical analysis to rank and select pulp mills in the Pacific Northwest region with the necessary combination of biogeophyscial and social assets to support retrofitting into a biorefinery. This analysis has led to an invited presentation at the Northwest Wood Based Biofuels Coproducts Conference in Seattle WA, and an R&R (currently re-submitted) for a manuscript submitted to Biomass and Bioenergy. A manuscript on the refined CAAM has been developed, and has been submitted to Politics and Life Sciences.

Publications

Peer-reviewed journal publications:

Martinkus, N. Rijkhoff, S.A.M., Hoard, S.A., Shi, W., Smith, P., Gaffney, M., & Wolcott, M. (submitted, R&R). Biorefinery Site Selection Using a Stepwise Biogeophysical and Social Analysis Approach. *Biomass and Bioenergy.*
Rijkhoff, S.A.M., Hoard, S., Gaffney, M., Smith, P. (submitted). Communities Ready for Takeoff: Integrating Social Assets for Biofuel Site-selection Modeling. *Politics and Life Sciences.*

Outreach Efforts

Martinkus, N., Rijkhoff, S., **Hoard, S.,** Shi, W., Smith, P., M. Gaffney. *A Stepwise Biogeophysical and Social Analysis to Approach Site Selection of Biorefineries,* Northwest Wood Based Biofuels Coproducts Conference, May, Seattle, WA.
Mueller, D., **Hoard, S.,** Sanders, C., Gaffney, M., P. Smith. *Strategic Applications of the Community Assets and Attribute Model* [poster]. Aviation Sustainability Center (ASCENT) Meeting, September, Washington D.C.

Awards

None

Student Involvement

Daniel Mueller, Ph.D. candidate in political science at WSU and research assistant on this project, will continue validation efforts for the CAAM and help develop measurements for political capital.

Kelli Roemer, Master's student of natural resources at the University of Idaho, is continuing validation work of the CAAM as part of her thesis work.

Plans for Next Period

Subsequent development of the CAAM will include inclusion of political capital through aggregation of national data on local and national elections at the county level, and development of alternative measures of creativity that rely on publically available indicators. Plans are currently underway to extend the research to Canada.

WSU 5. Refine and deploy the facility siting tools for determining regional demand and potential conversion sites to be used in regional analyses.

Washington State University

Objective(s)

Refine and deploy the facility siting tools for determining regional demand and potential conversion sites to be used in regional analyses.

Research Approach

Building on two iterations of the CAAM model developed under the NARA project, the ASCENT applications for this subtask include substituting original data for previously-used aggregated sources, statistically testing and validating the model, refining the comparative benchmarks used to establish county-level ratings on the three community capitals (Social, Human, Cultural) previously incorporated into the model, and collecting case study information for use in further validation of the model's efficacy. The research remains focused on refining a model which is based on readily available national datasets (aggregated at the county level) which can be used to conduct a preliminary assessment of community characteristics for three (Cultural, Social, Human) of the seven "Community Capitals" framework. (Emery, Mary and Cornelia Flora. 2006. "Spiraling Up: Mapping Community Transformation with the Community Capitals Framework." Journal of the Community Development Society, Vol. 37, p. 22.) which informs the NARA project.

This year we are working on the development of readiness level tools for regional projects. In the past year, we have integrated the factored TEA analysis approach into facility siting analysis to weigh the value of retrofitting or colocating biorefinery assets. This approach was demonstrated on a cellulosic Alcohol-to-Jet supply chain in the Pacific Northwest. In the upcoming year, we will demonstrate the tool for supply chain and siting analysis for the alternative jet fuel production using FOGs converted from HEFA in the same region.

Milestone(s)

CAAM v.3.0 statistically analyzed and validated. We are currently developing readiness level tools for regional projects

Major Accomplishments

During this reporting period, further research and validation of The CAAM has been conducted. Further validation and refinement has included incorporating standard deviation comparisons in an effort to more easily illustrate where cases fall on rankings for each asset (community capital) compared to the defined regional average, and beginning development of gradation measurement of capital comparative status through incorporation of standard deviations to examine distance from regional averages and impacts on development and implementation success. The CAAM model with reported standard deviations was combined with biogeophysical analysis and presented at the Northwest Wood Based Biofuels Coproducts Conference, and a manuscript has been submitted to Biomass and Bioenergy. Suitable case study sites have been identified for ground truthing, which will lead to further validation and refinement of the model. National datasets on voting trends in local and national elections have been acquired, aggregated at the county-level and will be added to the model to include a fourth important community capital – political capital.

Publications

None

Outreach Efforts

None

Awards

None

Student Involvement

Daniel Mueller, Ph.D. candidate in Political Science, now holds a funded Research Assistant appointment working on this project, and has been primarily responsible for acquisition of new primary data, further validation of the model, and the (continuing) development of the fourth iteration of the CAAM.

Kelli Roemer, Master's student of natural resources at the University of Idaho, is continuing validation work of the CAAM as part of her thesis work.

Plans for Next Period

In the next year, a new iteration of the CAAM will be fully developed, validated, and applied in the NARA and BANNER regions, with expansion to the Midwest region. This model will be based upon: (1) Addition of new data to support addition of the fourth Political Capital to the model through ground truthing, case study analysis, and addition of National voting datasets at the county-level. (2) Development of more refined measurement of capital comparative ranking beyond dichotomous outperform/under perform ratings using standard deviations to examine distance from regional average and impact on successful development and implementation. (3) Alternative Creative Vitality aggregate measure developed from alternative primary source data in order to support updated, and more robust analyses and modelling. (4) Final validation, after statistical confirmation, using selected case studies to confirm the efficacy of the model.

The Fourth CAAM will be available for use nationally, allowing comparison of counties against defined regional norms on Cultural, Social, Human, and Political Capital scales that have been statistically tested and validated through triangulated testing with external data.

Task WSU 6. Refinery to Wing Stakeholder

Washington State University

This is a shared task lead by Penn State University. The reporting is provided in Award No. 13-C-AJFE-PSU-002.

Objective(s)

Complete assessment of key aviation fuel supply chain stakeholder perceptions regarding the conditions necessary for the adoption and diffusion of AJF in the NARA region. Assess perceptions in another US MASBI region

Research Approach

The team will collect primary data via interviews and surveys to better understand the awareness, opinions, and perspectives of key aviation fuel supply chain stakeholders regarding to the potential impacts and key success factors for an economically viable biojet fuel production industry in the NARA and US Midwest region. These aviation fuel supply chain stakeholders include airport management, FBOs, other aviation fuel handlers, relevant airlines, and CAAFI personnel. Databases of regional aviation fuel supply chain stakeholders will include airport management, FBOs, fuel resellers, terminal and pipeline operators, and the airlines. This effort will be conducted jointly with Volpe where appropriate. Data collection to assess aviation fuel supply chain stakeholder opinions, awareness, and perceptions regarding factors impacting the adoption and diffusion of AJF in the NARA region has been completed. Data collection through interviews with aviation stakeholders in the US Midwest region is currently underway, and a national survey of aviation management is being developed and will be fielded in early 2017 after consultation with CAAFI.

Milestone(s)

Assessment in the Pacific Northwest region of stakeholder perceptions using interviews and a survey of airport management have been completed, resulting in one published paper and a manuscript currently in progress.

Major Accomplishments

The team has completed stakeholder assessment interviews and surveys in the Pacific Northwest NARA region and has published a paper on interview results from this region. A second manuscript is currently in progress detailing the survey results from stakeholders in the same region. Interview contacts in the Midwest have been established and a first round of interview requests has been sent out.

Publications

Smith, P.M., Gaffney, M.J., Shi, W., Hoard, S., Ibarrola Armendariz, I., Mueller, D.W., 2017. Drivers and Barriers to the Adoption and Diffusion of Sustainable Jet Fuel (SFJ) in the U.S. Pacific Northwest. *Journal of Air Transport Management, 58*, 113-124.

Outreach Efforts

Mueller, D. **Hoard, S.,** Smith, P. Sanders, C., M. Gaffney. *Airport Management Perceptions of Aviation Biofuels in the Pacific Northwest* [poster]. Aviation Sustainability Center (ASCENT) Meeting, April, Alexandria, VA.

Smith, P., Gaffney, M., Shi, W., **Hoard, S.,** Ibarrola Armendariz, I., D.M. Mueller. *Aviation Fuel Supply Chain Stakeholder Perceptions in the PNW,* Aviation Sustainability Center (ASCENT) Meeting, April, Alexandria, VA.

Mueller, D., **Hoard, S.,** Smith, P., Sanders, C., M. Gaffney. *Stakeholder Perceptions of Aviation Biofuels in the PNW,* Northwest Wood Based Biofuels Coproducts Conference, May, Seattle, WA.

Smith, P., Gaffney, M., Shi, W., **Hoard, S.,** Ibarrola Armendariz, I., D.M. Mueller. *Aviation Fuel Supply Chain Stakeholder Perceptions in the PNW,* Northwest Wood Based Biofuels Coproducts Conference, May, Seattle, WA.

Awards

None

Student Involvement

Daniel Mueller, Ph.D. candidate in political science at WSU and research assistant on this project, has aided in writing and publishing NARA interview results and is currently involved in the interview process for the Midwest, gathering contact information, aiding in question development, and contacting potential interviewees.

Joseph Rogachevsky, Master's student in BioRenewable Systems (BRS), has aided in gathering contact information for interviews and has contacted stakeholders to set up interviews.

Plans for Next Period

The next year will see the completion of the stakeholder assessment in the Midwest, with the team continuing to gather contact information of stakeholders in the region. A national survey is also being developed, and will be sent out to aviation management stakeholders throughout the country. Plans are currently underway to replicate the research in Canada.

Task WSU 7. Supply Chain Analysis

Washington State University-Volpe

Objective(s)

Use the design cases developed in previous years for standalone alternative jet fuel production technologies to estimate production volumes and breakeven price for all the facilities identified by the Volpe Center. This effort will continue towards the continual refinement of the FAA aspirational jet fuel production goal.

Research Approach

Our team will use the design cases developed in previous years for standalone alternative jet fuel production technologies to estimate production volumes and breakeven price for all the facilities identified by the Volpe Center. Our expectation is that Volpe will provide us with a list of potential facilities, their throughput capacity, price of the feedstock at the gate and we will estimate the capital investment, operational costs and beakeven cost for each of the facilities.

Milestone(s)

Our team has been providing Volpe with information that will allow them to use the design cases developed in previous years for standalone alternative jet fuel production technologies to estimate production volumes and breakeven price.

Major Accomplishments
The team is in contact with Volpe to support them in the Supply chain analyses.

Publications
None

Outreach Efforts
None

Awards
None

Student Involvement
A graduate student (Lina Martinez) is receiving training (taking courses) to contribute in this task.

Plans for Next Period
Participate in the development of supply chain analysis tasks.

Task WSU 8 Analytical Support for regional CAAFI and USDA jet fuel project
Washington State University

Objective(s)
Develop a readiness level tool to assess the status of regional alternative jet production projects. In addition, use the supply chain and standalone design cases to support the USDA BANR project in TEA and supply chain analysis. This regional CAP project focuses on the use of softwood forest salvage feedstock for fuels via a catalyzed pyrolysis conversion pathway.

Research Approach
We will develop readiness level tools for regional projects to assess their status of developing fuel project and assist in understanding critical missing components. This tool, will take similar form and approaches to the CAAFI Feedstock and Fuel Readiness Levels and will be used to assist CAAFI in understanding the stage of development for projects of interest and assess critical gaps. In addition, we will assist the regional USDA BANR team in deploying TEA and Supply Chain analysis to their project. This effort is structured around using softwood forest salvage feedstock with a thermochemical conversion process to produce fuels and coproducts.

Milestone(s)
We are progressing on the use of the supply chain and standalone design cases to support the USDA BANR project in TEA and supply chain analysis.

Major Accomplishments
In contact with the USDA BANR project.

Publications
None

Outreach Efforts
None

Awards
None

Student Involvement
None

Plans for Next Period
To work with the USDA BANR team in TEA and supply chain analyses.

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