Project 001(A) Alternative Jet Fuel Supply Chain Analysis

Washington State University

Project Lead Investigator

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University Participants

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- P.I.(s): Michael P. Wolcott, Regents Professor; Christina Sanders, Acting Director, DGSS; Manuel Garcia-Perez, Associate Professor; and Xiao Zhang, Associate Professor
- FAA Award Number: 13-C-AJFE-WaSU-013
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- Task(s):
    - WSU 1. Design cases– Garcia-Perez, Zhang
    - WSU 2. Evaluation of the most promising biorefinery concepts for AJF production. Garcia-Perez, Zhang
    - WSU 3. Supplement and maintain the current inventory of biorefinery 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

$396,037 FAA funding and $396,037 matching funds. State committed graduate school contributions for four PhD students. Faculty time, Michael Wolcott, Manuel Garcia-Perez and Xiao Zhang are contributing to cost shared.

Investigation Team

- Michael Wolcott, Project Director/Principal Investigator
- Christina Sanders, Co-Project Director(s) /Co-Principal Investigator (Co-PI)
- Season Hoard, Co-Project Director(s)/Co-Principal Investigator (Co-PI)
- Manuel Garcia-Perez, Co-project Director(s)/Co-Principal Investigator
- Xiao Zhang, Co-project Director(s)/Co-principal Investigator
- Paul Smith, Faculty
- Michael Gaffney, faculty
- Kristin Brandt, Staff Engineer
- Natalie Martinkus, Staff Engineer
- Sarah Dossey, Staff Engineer
- Scott Geleynse, post-doctoral (100 %)
- Dane Camenzind, Graduate Student
- Lina Pilar Martinez Valencia, Graduate Student
- Tanzil Abid Hossain, Graduate Student

- Anamaria Paiva, Graduate Student
- Daniel Mueller, Graduate Student
- Kelly Nguyen, 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 coproducts on the development of jet fuel production scenarios has to be considered in future studies.

The design cases of the standalone AJF production facilities will be used in supply chain evaluations. Community Social Asset Modeling (CAAM): Social Asset modeling is not well-developed, and efforts are likely hampered by the difficulty in quantifying social assets when compared to improved environmental performance or a reduction in biofuel costs that may be observed by optimizing economic and environmental constraints. However, considering the community characteristics of a potential site is important when determining preferred locations for a new biorefinery. Community resistance or enthusiasm for the biofuels industry can play a large role in the success or failure of a facility (Martinkus et al 2014). CAAM efforts conducted within this project will inform disciplinary applications and advances. It is clear that social factors can have a significant effect – positive or negative – on project adoption and implementation, especially high technology or energy-related projects (Lewis et al 2012, Martinkus et al 2012). Accounting for social factors to inform selection of sites and implementation decisions to maximize positive social support and minimize opposition and social negatives can significantly enhance project success. The CAAM model originally piloted in the NARA project is designed to provide a quantitative rating of select social factors at the county level (Martinkus et al 2014).

This research is targeted at identifying the key barriers in regional supply chains that must be overcome to produce 1-billion gallons of alternative jet fuel. This overall goal is addressed by developing tools to support the AJF supply chain assessment by the Volpe Center. Our effort will provide facility siting analyses that assess (a) conversion design cases combined with (b) regional supply chain assets and (c) social capacity assessments for communities to act collectively for development goals.

Finally, a refinery-to-wing stakeholder assessment will support modeling and accounting of AJF distribution for downstream fuel logistics.

Task #1: Design Cases

Washington State University

Objective(s)

Continuation from previous years

Our team will complete the reviews and final report of the design cases for six standalone AJF technologies and four important industries (sugarcane, pulp and paper, corn ethanol and petroleum refineries) developed in previous years and will start developing the design cases for targeted co-products that could improve the economic viability of AJFs.

New Tasks

(1) New case design report "Alternative Jet Fuel Supply Chain Analysis: hydrothermal liquefaction processing of tall oil for jet fuel production". This work involved collecting primary data, establishing process flow diagram and conducting a detailed TEA. This task will be carried out in collaboration with PNNL HTL group. **(2)** Conduct detailed TEA analyses of integrating lignin co-products technologies in Alcohol-to-Jet pathway to determine the potential to lower fuel cost to $2.00/gge.**(3)** New design case reports on technology review and process evaluation of lipid conversion processes (HEFA, CH, SBI, Forge, Tyton, decarboxylation) and new technologies for the production of alternative lipids (HTL and sugars to lipid). **(4)** Conduct detailed TEA analysis integrating lignin co-products technologies in biorefinery cases integrated with the corn ethanol, and the sugarcane 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 biorefinery concepts around the Petroleum Refineries, Pulp and Paper Mills, Sugar Cane Mills, and Corn Ethanol Mills. Then we will compare the biorefinery concepts developed for each of these technologies to decide the most promising ones. The most promising biorefinery 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 has 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.

Last year we continued refining the design cases developed for four 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), as well as for four important industries; sugarcane, pulp and paper, corn ethanol and petroleum refineries. We have addressed all the comments received from our internal reviewers, and from our industrial reviewers. In the last six months we have been standardizing the design cases so that they can be used by our partners. The design case for the Hydrotreated depolymerized cellulosic jet consisting in a literature review, the mass and energy balances and the economic analysis was submitted in October. The design case for the Virent technology and the Alcohol to Jet technology are under review and will be submitted before the end of the year. The design cases for three of the industrial infrastructure (corn ethanol, and sugarcane mill) are completed and will be soon submitted for review and standardization. We are currently working to submit for revisions and standardization the petroleum refinery design case by March 2018. We are drafting a manuscript of integration of ATJ technologies in chemical pulp mill infrastructure. At the request of FAA, this year we started developing design cases for HEFA and FT. The first draft of these design cases will be available by the end of the year. We are also working in a literature review of other technologies for lipid conversion (CH, SBI, Forge, Tyton, decarboxylation) and new technologies for the production of alternative lipids (HTL and sugars to lipid). This literature review will be completed by the summer 2018.

We are working on completing a design case report of “lignin co-products opportunities from advanced fermentations based AJF processes”.

We are working with PNNL to complete a case design report on HTL for AJF conversion. This work involved collecting primary data, establishing process flow diagrams for several feedstocks including, municipal waste (primary and secondary), Algae and tall oil, and conducting a detailed TEA. We have discussed the draft report with PNNL. We will also work with PNNL to help identify ways to improve HTL conversion efficiency.

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 review by team members and external reviews completed. We are currently standardizing all the design cases and one design case for alternative jet fuel production was released for use by team members early in October. Three more will be released by the end of the year. The design cases for the corn ethanol and the sugarcane industry are under review by the standardization team. The design case for the petroleum refinery will be available by the summer 2018. The design cases for HEFA and micro-reactors FT are under construction and should be completed by the end of the year. We will complete the design cases report for Lignin co-products, pulp and paper mills by the end of this year. A detailed HTL designed cased report will be completed by March 31st 2018.

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 biorefinery concepts. The methodology for these models is 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, 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 the AJFs into commercial jet fuel.

Most of the design cases have undergone external review and are currently under review by the standardization team for public release.

Publications

Scott Geleynse, Kristin Brandt, Manuel Garcia-Perez, Michael Wolcott, Xiao Zhang, The Alcohol to Jet Conversion Strategy for Drop in Biofuels. Evaluation of Technical Aspects and Economics (manuscript reviewed by Gevo and John Holladay at

PNNL, currently under review by FAA, a copy of draft manuscript was also sent to LanzaTech). To be submitted for Journal publication by the end of Nov. 2017.

Outreach Efforts
None – Task in Progress

Awards
None – Task in Progress

Student Involvement
Several graduate (Scott Geleynse, Mond Guo, Carlos Alvarez Vasco, Ruoshui Ma, Kelly Nguyen, Tanzil Hossain, Anamaria Paiva, Lina Martines) 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
Complete the design cases for HEFA and FT-micro-reactors. Literature review on other technologies for alternative jet fuel production from lipids. Release of all design cases for standalone AJF production technologies, for relevant infrastructure and for co-products from lignin.

Task #2: Evaluation of the Most Promising Biorefinery Concepts for AJF Production
Washington State University

Objective(s)

Continuation from previous years
This year we will complete the evaluation of biorefinery scenarios for AJF production in corn ethanol, sugarcane and pulp and paper mills and petroleum refineries. Last year we advanced the analysis for corn ethanol and pulp and paper mills. This year we should complete the analysis for sugarcane and petroleum refineries.

New Tasks
Conduct detailed TEA analyses of integrating lignin co-products technologies Direct Sugars to Hydrocarbons (DSHC) pathway to determine the potential to lower fuel cost to $2.00/gge.

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 biorefinery concepts for Petroleum Refineries, Pulp and Paper Mills, Sugarcane Mills and dry corn mills. The results from this effort will allow us to identify and select the most commercially feasible biorefinery concepts. Major technical gaps/barriers toward commercialization of each of the biorefinery 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 bio-refinery scenarios for AJF production. Five alternative jet fuel (AJF) technologies were studied: Virent's BioForming, "Gevo" alcohol to jet (ATJ), direct sugar to 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. The comparison of sugarcane bio-refinery concepts for aviation fuel production has progressing well. In January 2018 we plan to start will the analysis of petroleum refineries biorefinery concepts.

We will complete a draft paper of integration of ATJ technologies in pulp mill infrastructure this year. We will then apply this methodology for analyzing other advanced fermentation technology (direct sugar to hydrocarbon by Amyris) in pulp mill next year. We will also expand the lignin co-product analysis to all other AJF pathways.

Major Accomplishments

Economic models and Life Cycle Assessments were used to support the selection of the most promising bio-refinery concepts for the corn ethanol plant. A manuscript on corn ethanol bio-refineries will be submitted shortly.

Publications

We plan to complete the manuscript preparations of “integration of ATJ to pulp mill infrastructure” and “Lignin co-products opportunities to improve AJF production in advanced fermentation conversion pathways” by June 30th 2018.

- Tanzil, AH, Zhang X, Wolcott M, Garcia-Perez: Evaluation of Biorefinery Alternatives for the Production of Jet Fuels in a Dry Corn Ethanol Plant. Paper to be submitted to Biofuels, Bioproducts and Biorefinery, 2018
- Martinkus, N., Rijkoff, S.A.M., Hoard, S.A., Shi, W., Smith, P., Gaffney, M. & Wolcott, M. (2017). Biorefinery site selection using a stepwise biogeophysical and social analysis approach. Biomass and Bioenergy, 97, 139-148. doi:10.1016/j.biombioe.2016.12.022
- Rijkhoff, S.A.M., Hoard, S., Gaffney, M.J. & Smith, P.M. (2017). Communities ready for takeoff: Integrating social assets for biofuel site-selection modeling. Politics and the Life Sciences, 36(1):14-26. doi:10.1017/pls.2017.6

Outreach Efforts

Tanzil, AH, Geleynse S, Garcia-Perez M, Zhang X, Wolcott M: Alternative Jet Fuel Production in Integrated Biorefuneries Using Existing Dry Corn Mill: Cost Reduction Opportunities. ASCENT Meeting, September 27-28, 2016

Awards

None

Student Involvement

Graduate students Scott Geleynse, Senthil Subramaniam, Kelly Nguyen, Abid Tanzil Houssain, Lina Martinez Valencia, Anamaria Paiva, 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. Dr. Zhang’s team will complete the HTL case design report and lignin analysis report.

Task #3: Supplement and Maintain the Current Inventory of Bio-Refinery Infrastructure Identified In the Conversion Design Cases That Are Useful For Production of AJF

Washington State University

Objective(s)

Continuation from previous years
This task requires annual evaluation of the database to add or eliminate new and closed 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. In order 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
Nothing to report

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 #4: Continue Work On Social Asset Decision Tools Developed In Phase 1 For Plant Siting (Community Asset & Attribute Model—CAAM); Including Additional Validation And Incorporation Of Multi-Decision Making Tools. Extend Application To Another US Region In Coordination With Other Team Members (Inland Northwest, Appalachian Region). Prepare For Extension Nationally & Replication in Select Countries

Washington State University

Objective(s)

Continue to build on social asset decision tools for plant siting (Community Asset & Attribute Model—CAAM) through addition of political capital. Prepare for extension nationally & replication for Canada, and select EU countries.

Research Approach

Based on key measures of social, cultural, human, and political capitals, WSU has developed and refined a Community Asset and Attribute Model (CAAM). The first tool was initially applied to the NARA region, and the refined tool that added more complete measures of social, cultural, and human capital was deployed in two sub-regions of NARA in the Pacific Northwest. The initial measure of political capital has now been added to the CAAM, and the tool can be used across the continental United States. The refined CAAM (excluding the political capital) has been used to assess social capacity for biorefinery siting in two separate studies, including retrofitting paper mill facilities in the Pacific Northwest. Ground-truthing analysis was used to assess the role of social, cultural and human capitals in the success or failure of biofuel related projects in both the NARA and BANR regions. This ground-truthing analysis supported the role of CAAM measures in project success, and suggested opportunities to further improve the CAAM which we are currently working to incorporate. The CAAM has undergone another refinement and now includes measurements for political capital. The ways in which each capital is measured have also been altered for each capital. This overhaul necessitates another effort to validate the model, which is currently underway. Work is also underway to develop approaches to apply the CAAM strategically providing guidance to stakeholders on methods of approaching communities and stakeholders to aid successful development and implementation.

Milestone(s)

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

Major Accomplishments

A paper on the refined CAAM will be published by Politics and the Life Sciences in 2017, the manuscript details the model's measurements of cultural, human, and social capital and presents validation of the model based on case studies from the Pacific Northwest. A step-wise analysis that combines biogeophysical and social assets to examine retrofitting pulp mills in the Pacific Northwest has been published in Biomass and Bioenergy. The updated CAAM with the addition of political capital was also presented at the WSU Sustainability Fair.

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

Mueller, D., Hoard, S., Sanders, C., & Gaffney, M. *The Community Assets and Attributes Model: Refining and Updating Measurements for Social Assets*. Fall 2017 ASCENT Advisory Committee Meeting. Alexandria, VA.

Mueller, D., Hoard, S., Sanders, C., Gaffney, M., & Smith, P. *Strategic Applications of the Community Assets and Attribute Model*. Washington State University Sustainability Fair. Pullman, WA.

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 has developed measurements for political capital. He will also continue work on developing strategic applications of the CAAM.

Kelli Roemer, Master's student of natural resources at the University of Idaho, has completed validation work of the CAAM as part of her thesis work. She has completed her thesis, receiving her M.S.

Plans for Next Period

Subsequent development of the CAAM will include further validation efforts of the overhauled version of the model that now includes political capital and new measurements for the other social assets. Strategic application of the CAAM will also be examined, which includes developing strategies to go beyond the model's ability to quantitatively identify ideal communities and include considerations for political support of biofuels and the potential for sustainable outcomes. This year the CAAM model will be further developed by incorporating multi-method decision-making tools, including semi-quantitative weighting approaches, for better inclusion in current biogeophysical, economic, and systems analysis.

Task #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)

Continuation from last year

Develop readiness level tools for regional projects.

Research Approach

The CAAM model developed under the NARA project, and refined for ASCENT applications, provides county-level data collected from national datasets (to conduct a preliminary assessment of community characteristics for now four (Cultural, Social, Human, Political) of the seven "Community Capitals" framework (Emery and Flora. 2006)."

To help improve facility siting tools, prior CAAM models (focusing on 3 assets: social, cultural, and human capital) have been added to biogeophysical assets to assess suitability of communities in the Pacific Northwest for bio-refineries. Expanding on these analysis, our CAAM measures have been added to a decisional support tool to assess re-purposing pulp mills in the Pacific Northwest for a biorefinery. These approaches have been utilized for cellulosic Alcohol to Jet supply chains in the Pacific Northwest, and we will work to demonstrate the tool for supply chain and siting analysis for the alternative jet fuel production using FOGs converted from HEFA in the Inland Northwest.

Milestone(s)
CAAM has been updated with four capitals, and readiness level tools for regional projects are being developed.

Major Accomplishments
During this reporting period, ground truthing of CAAM has been completed, and a Master's thesis based on this analysis was completed this summer. Further validation and refinement has led to the incorporation in an updated Decision Support Tool for the Pacific Northwest and the addition of political capital. National datasets on voting trends in local and national elections are currently being assessed for incorporation in strategic intervention modeling.

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, the new iteration of the CAAM that includes updated data and the addition of political capital will be validated and applied in the NARA and BANR regions, with expansion to at least one additional U.S. region (Inland Northwest and potentially Central Appalachian Region in cooperation with Team members). This model is based upon the addition of measurements for political capital, 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, alternative measurements for cultural capital and slight changes in measurements for human and social capitals, and final validation, after statistical confirmation, using selected case studies to confirm the efficacy of the model.

The updated CAAM is 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. The new version of the CAAM allows for further enhancing predictive capacity through the development of strategic applications of the model, including, for example, the level of political support for biofuels in any given community.

Task #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)

Continuation from last year
Extend Stakeholder assessment to a limited sample of informed stakeholders in the remaining sections of the country to provide insight into market & industry dynamics which will help optimize successful outcomes.

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 United States, and specifically the Pacific Northwest and US Midwest region. These aviation fuel supply chain stakeholders include airport management, FBOs, other aviation fuel handlers, relevant airlines, and CAAFI personnel. Data collection to assess aviation fuel supply chain stakeholder opinions, awareness, and perceptions regarding factors impacting the adoption and diffusion of AJF in the Pacific Northwest region has been completed, and Midwest region analysis is continuing. A national survey of aviation management is being developed and will be fielded in early 2018 after consultation with CAAFI and FAA. A survey to replace interviews in the Midwest Region is currently being developed, and will be deployed in other regions when complete.

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 submitted. Interview requests for stakeholders in the Midwest have been sent out, and there has been a limited response. One interview has already been conducted.

Major Accomplishments
The team has completed stakeholder assessment interviews and surveys in the Pacific Northwest, publishing a paper on interview results from this region. A second manuscript is currently submitted for publication detailing the survey results from stakeholders in the same region. Interview contacts in the Midwest have been established and a third round of interview requests has been sent. We have received potential contacts from an interview participant, and are working to include these contacts to get corporate participation from key fuel distributors in the region.

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 (SJF) in the U.S. Pacific Northwest. *Journal of Air Transport Management, 58*, 113-124.

Outreach Efforts
None

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.

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 has also been developed, and will be sent out to aviation management stakeholders throughout the country. Plans are currently underway to replicate the research in Canada.

Task #7: Supply Chain Analysis
Washington State University-Volpe

Objective(s)

Continuation from previous years
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 toward the continual refinement of the FAA aspirational jet fuel production goal.

Research Approach
We use the conversion design cases for standalone alternative jet fuel production technologies to estimate production volumes and breakeven price for all the facilities identified by the Volpe Center in their AFTOT analysis. Geospatially specific layers are produced for waste feedstock and incorporated into the AFTOT analysis.

Milestone(s)
Our team provided Volpe data developed in previous years for standalone alternative jet fuel production technologies to estimate production volumes and breakeven price. A nation-wide analysis to estimate the ability to produce 1-billion gals of AJF in the US.

Major Accomplishments
WSU and the Volpe AFTOT analysis team has teamed with the NREL BSM team for a joint analysis of the ability to reach 1-billion gallon of AJF production in the US.

Publications
A publication has been prepared and is in review.

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 #8: Analytical Support for Regional CAAFI and USDA Jet Fuel Project
Washington State University

Objective(s)

Continuation from previous years
Develop a readiness level tool to assess the status of regional alternatives 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. We have supported the BANR team in creating TEAs for the technologies under consideration.

Major Accomplishments

In collaboration with the USDA BANR project and attending their annual meeting to coordinate analysis. We currently await their completion of beetle-killed softwood estimates to complete the supply chain analysis.

Publications

None

Outreach Efforts

None

Awards

None

Student Involvement

None

Plans for Next Period

To complete a supply chain analysis that assesses the role of depots. Draft paper to be complete by end of next quarter.

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