Project 001(B) Alternative Jet Fuel Supply Chain Analysis

University of Hawaii

Project Lead Investigator

University of Hawaii Lead
Scott Q. Turn
Researcher
Hawaii Natural Energy Institute
University of Hawaii
1680 East-West Rd., POST 109; Honolulu, HI 96822
(808) 956-2346
sturn@hawaii.edu

University Participants

University of Hawaii

- P.I.(s): Scott Q. Turn, Researcher
- FAA Award Number: 13-C-AJFE-UH, Amendment 005
- Period of Performance: 10/1/15 to 9/30/18
- Task(s):
    1. Informing Regional Supply Chains
    2. Identification of Supply Chain Barriers in the Hawaiian Islands

University of Hawaii

- P.I.(s): Scott Q. Turn, Researcher
- FAA Award Number: 13-C-AJFE-UH, Amendment 007
- Period of Performance: 10/1/16 to 9/30/18
- Task(s):
    1. Informing Regional Supply Chains
    2. Support of Indonesian Alternative Jet Fuel Supply Initiatives

University of Hawaii

- P.I.(s): Scott Q. Turn, Researcher
- FAA Award Number: 13-C-AJFE-UH, Amendment 008
- Period of Performance: 8/1/17 to 9/30/18
- Task(s):
    1. National lipid supply availability analysis
    2. Hawaii regional project

Project Funding Level

Under **FAA Award Number 13-C-AJFE-UH, Amendment 005**, the Alternative Jet Fuel Supply Chain Analysis-Tropical Region Analysis project received $75,000 in funding from the FAA and cost share funding of $75,000 from the State of Hawaii.

Under **FAA Award Number 13-C-AJFE-UH, Amendment 007**, the Alternative Jet Fuel Supply Chain Analysis-Tropical Region Analysis project received $100,000 in funding from the FAA and cost share funding of $75,000 from the State of Hawaii and $25,000 of in-kind cost match in the form of salary support for Scott Turn from the University of Hawaii.

Under **FAA Award Number 13-C-AJFE-UH, Amendment 008**, the Alternative Jet Fuel Supply Chain Analysis-Tropical Region Analysis project received $125,000 in funding from the FAA and cost share funding of $125,000 from the State of Hawaii.

Investigation Team

Lead
Scott Turn – University of Hawaii

Other Lead Personnel
Tim Rials and Burt English (UT Co-PIs)
Manuel Garcia-Perez (WSU Co-PI)
Kristin Lewis (Volpe PI)
Michael Wolcott (WSU PI)

UH Investigation Team
Under **FAA Award Number 13-C-AJFE-UH, Amendment 005**, Task 1 and Task 2 includes
Dr. Scott Turn, Researcher, Hawaii Natural Energy Institute, UH
Dr. Trevor Morgan, Assistant Researcher, Hawaii Natural Energy Institute, UH
Dr. Richard Ogoshi, Assistant Researcher, Department of Tropical Plant and Soil Sciences, UH
Dr. Adel H. Youkhana, Junior Researcher, Department of Tropical Plant and Soil Sciences, UH

Under **FAA Award Number 13-C-AJFE-UH, Amendment 007**, Task 1 and Task 2 includes
Dr. Scott Turn, Researcher, Hawaii Natural Energy Institute, UH
Dr. Trevor Morgan, Assistant Researcher, Hawaii Natural Energy Institute, UH
Dr. Richard Ogoshi, Assistant Researcher, Department of Tropical Plant and Soil Sciences, UH
Dr. Adel H. Youkhana, Junior Researcher, Department of Tropical Plant and Soil Sciences, UH
Dr. Curtis Daehler, Professor, Department of Botany, UH
Ms. Sharon Chan, Junior Researcher, Hawaii Natural Energy Institute, UH

Under **FAA Award Number 13-C-AJFE-UH, Amendment 008**, Task 1 and Task 2 includes
Dr. Scott Turn, Researcher, Hawaii Natural Energy Institute, UH
Dr. Trevor Morgan, Assistant Researcher, Hawaii Natural Energy Institute, UH
Dr. Jinxia Fu, Assistant Researcher, Hawaii Natural Energy Institute, UH
Ms. Sabrina Summers, undergraduate student, Bioengineering Department, UH
Mr. Kyle Marcelino, undergraduate student, Bioengineering Department, UH
Mr. Taha Elwir, undergraduate student, Chemistry Department, UH

Project Overview

Under **FAA Award Number 13-C-AJFE-UH, Amendment 005**, the 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 in tropical regions. Outputs from this project may be used as inputs to regional supply chain analyses being developed by the FAA and Volpe Center. The second objective is to identify the key barriers in regional supply chains that must be overcome to produce significant quantities of alternative jet fuel in the Hawaiian Islands and similar tropical regions.

The **FAA Award Number 13-C-AJFE-UH, Amendment 005** project goals are to:

- Review and summarize:
  - the available literature on biomass feedstocks for the tropics,
  - the available literature on pretreatment and conversion technologies for tropical biomass feedstocks,
  - the available literature on geographic information systems data sets available for assessment of alternative jet fuel production systems in the tropics.
- Identify alternative jet fuel supply chain barriers in the Hawaiian islands

Under **FAA Award Number 13-C-AJFE-UH, Amendment 007**, the 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 in tropical regions. Outputs from this project may be used as inputs to regional supply chain analyses being developed by the FAA and Volpe Center. Included in this objective is the development of fundamental property data for tropical biomass resources to support supply chain analysis. The second objective is to support the Memorandum of Understanding

between the Federal Aviation Administration (FAA) and Indonesian Directorate General of Civil Aviation (DGCA) to promote developing and using sustainable, alternative aviation fuels.

The **FAA Award Number 13-C-AJFE-UH, Amendment 007** project goals are to:

- Support the Volpe Center and Commercial Aviation Alternative Fuels Initiative (CAAFI) Farm to Fly 2.0 supply chain analysis.
- Use GIS-based estimates of fiber crop production potential to develop preliminary technical production estimates of jet fuel in Hawaii.
- Develop fundamental property data for tropical biomass resources.
- Transmit data and analysis results to other ASCENT Project 1 researchers to support improvement of existing tools and best practices.
- Support Indonesian alternative jet fuel supply initiatives.

Under **FAA Award Number 13-C-AJFE-UH, Amendment 008**, the research effort has two objectives. The first objective is to support a national lipid supply availability analysis that will inform industry development and guide policy. The second objective is to conduct a targeted supply chain analysis for alternative jet fuel production facility based on a Hawaii regional project.

The **FAA Award Number 13-C-AJFE-UH, Amendment 008** project goals are to:

- Support ASCENT partners conducting the national lipid supply availability analysis by contributing information on tropical oilseed availability.
- Evaluate supply chains for targeted waste streams and purpose grown crops in Hawaii to a location in the principal industrial park on the island of Oahu.

Task 0.1 – Informing Regional Supply Chains

University of Hawaii

Objective(s)

This task included two activities, (1) a review of the archival literature on existing tropical crops and potential new crops that could provide feedstocks for AJF production and (2) a review of relevant pretreatment and conversion technology options and experience with feedstocks identified in (1).

Research Approach

Activity 1. The archival literature will be reviewed to construct an updated database of relevant citations for the tropical crops; new potential energy crops will be identified and added to the database. Available information on agronomic practices, crop rotations, and harvest techniques will be included. The database will be shared with and serve as a resource for the Project 1 team and Volpe Center analyses of regional supply chains.

Activity 2. A database of relevant pretreatment and conversion technology options and experience with potential tropical feedstock materials will be assembled from the archival literature and from existing Project 1 team shared resources. Of particular interest are inventories of material and energy flows associated with the pretreatment and conversion unit operations, fundamental to the design of sustainable systems and the underlying analysis. Pairings of pretreatment and conversion technology options provide the starting point for evaluation of tropical biorefineries that can be integrated into ASCENT Project 1 team and Volpe Center activities.

Milestone(s)

Task 1, Activity 1: Identify target list of databases to search for relevant literature.
Task 1, Activity 1: Interim report summarizing progress on literature search.
Task 1, Activity 2: Identify target list of databases to search for relevant literature.
Task 1, Activity 2: Interim report summarizing progress on literature search.
Task 1, Activity 3: Identify target list of databases to search for relevant literature.
Task 1, Activity 3: Interim report summarizing progress on literature search.

Major Accomplishments
This work is largely completed. A report was produced for each of the two activities. The two reports were combined to form a manuscript that has been submitted for publication in the journal *Energy & Fuels*. Reviewer comments were received and are being addressed by the authors.

Publications
Morgan, T.M., A. Youkhana, R. Ogoshi, S. Turn, and M. Garcia-Perez. Review of biomass resources and conversion technologies for alternative jet fuel production in Hawai'i and tropical regions. *Energy & Fuels*. Reviewed and under revision.

Outreach Efforts
On February 21, 2108, the PI participated in a ThinkTech Hawaii broadcast focused on alternative jet fuels with collaborators from WSU and CAAFI, see https://www.youtube.com/watch?v=Ci4oWITPRKQ&feature=youtu.be

Awards
None

Student Involvement
None

Plans for Next Period
During the next period, the manuscript will be revised and published.

Task 0.2- Identification of Supply Chain Barriers in the Hawaiian Islands
University of Hawaii

Objective(s)
Identify the key barriers in regional supply chains that must be overcome to produce significant quantities of alternative jet fuel in the Hawaiian Islands and similar tropical regions.

Research Approach
UH developed the Hawaii Bioenergy Master Plan for the State of Hawaii [1]. Completed in 2009, UH was tasked with determining whether Hawaii had the capability to produce 20% of land transportation fuels and 20% of electricity from bio-based resources. Toward this end, the plan included assessments of (1) land and water resources that could support biomass feedstock production, (2) potential biomass resources and their availabilities, (3) technology requirements, (4) infrastructure requirements to support logistics, (5) economic impacts, (6) environmental impacts, (7) availability of human capital, (8) permitting requirements, and (9) limitations to developing complete value chains for biomass based energy systems. In keeping with the stakeholder driven development of the Hawaii Bioenergy Master Plan, barriers to development of regional supply chains for ASCENT will be identified by interacting with key stakeholder groups. Green Initiative for Fuels Transition Pacific (GIFTPAC) meetings are held quarterly and are attended by biofuel development interests in Hawaii including representatives of large landowners, producers of first generation biofuels, petroleum refiners, electric utilities, the State Energy Office, U.S. Pacific Command, biofuel entrepreneurs, county government officials, and the University of Hawaii. Additional stakeholders are invited as necessary to fill information and value chain gaps. These meetings are excellent opportunities to receive stakeholder input, identify barriers to supply chain development, and organize data collection efforts that span supply chain participants.

Milestone(s)
Include a description of any and all milestones reached in this research according to previously indicated timelines.

Task 2: Introduce activities at next regularly scheduled GIFTPAC meeting after contract executed.
Task 2: Interim report outlining two tropical supply chain scenarios developed in consultation with Project 1 team, and with input from GIFTPAC participants.

Major Accomplishments

This task is largely completed. A stakeholder meeting was held and documented in a report. The stakeholders identified barriers to alternative jet fuel production in Hawaii and ranked the barriers in order of importance as indicated below:

Economic constraints (e.g., high costs of entry for production factors such as land) throughout the whole production chain

- Issues associated with access to capital including high initial risks and uncertain return on investment
- Insufficient government support in the form of incentives and favorable policies to encourage long-term private investment
- Cost, availability and competition for water
- Alternative jet fuel production technologies are emerging but have not yet demonstrated full commercial viability
- Insufficient or inadequate infrastructure (e.g., harbors, roads, fuel distribution infrastructure, irrigation systems) to support the whole production chain

Several of the barriers are held in common with other locations in the continental U.S. but those related to water and infrastructure bear unique characteristics of an island state.

Publications

None

Outreach Efforts

This activity engaged stakeholders to identify barriers to alternative jet fuel production in Hawaii. Preparation included reviewing stakeholder lists from previous activities. Facilitators appropriate to the stakeholder group were retained. The stakeholder meeting included a presentation about the larger ASCENT program's scope and goals and the other aspects of the UH ASCENT project.

Awards

None

Student Involvement

None

Plans for Next Period

This task is complete but stakeholder outreach activities will continue under other tasks outlined below.

Task 0.3- Informing Regional Supply Chains

University of Hawaii

Objective(s)

Building on FY16 activities, additional supporting analysis will be conducted for proposed supply chains in Hawaii, including:

0.3.1 -Support Volpe Center and Commercial Aviation Alternative Fuels Initiative (CAAFI) Farm to Fly 2.0 supply chain analysis.

0.3.2- Use GIS-based estimates of fiber crop production potential to develop preliminary technical production estimates of jet fuel in Hawaii.

0.3.3- Develop fundamental property data for tropical biomass resources.

0.3.4- Transmit data and analysis results to support improvement of existing tools (e.g. POLYSIS).

Research Approach

Activity 0.3.2 has been conducted using geographic information system (GIS) data to identify areas suitable for purpose grown crop production of feedstocks for AJF production in Hawaii. The approach has been to use GIS layers for land capability class (LCC), slope and zoning as preliminary screens for suitability. Lands are classified by NRCS with ratings from 1 to 6. LCC's from 1 to 3 are generally suitable for agricultural production and LCC of 4 can be productive with proper management. LCC's of 5 or 6 can support less intensive production and could be suitable for forestry. The slopes of terrains impact aspects of production including mechanization and erodibility. An elevation GIS layer was used to derive a slope layer. Zoning layers were acquired from State and County GIS offices. Only agricultural zoning was deemed suitable for this analysis.

The EcoCrop model was used to develop yield models for the crops selected in Task 0.1 based on the annual rainfall and mean minimum monthly temperature data. EcoCrop includes model parameters on sugarcane, banagrass, 5 species of eucalyptus, leucaena, pongamia, jatropha, and sorghum. The parameters for sugarcane will be used to provide a base case assessment for comparison with historical sugar cane acreage and yield. Using sensitivity analysis, the model can be tuned to account for the differences between parameters developed from global sugar production and a century of production experience in Hawaii that was refined through plant breeding to adapt sugarcane varieties to a wide variety of agro-ecosystems. Model results across all of the potential feedstocks will be used to identify land use patterns that would match plants with environmental conditions toward maximizing productivity in support of AJF production.

Pongamia will be the initial focus of Activity 0.3.3. Pongamia is an oil seed bearing, leguminous tree that has production potential in Hawaii and Florida. The tree produces pods containing oil bearing seeds. Pods, oil seed cake, and oil will be evaluated from a number of trees growing on the island of Oahu. Fundamental measurements of chemical composition will be conducted and reported. Development of coproducts from the pods and oil seed cake will be explored.

Milestone(s)

- Identify target opportunities to augment POLYSYS, AFTOT, and conversion modules.
- Review previously developed GIS information layers for tropical fiber crops and identify updating requirements.
- Preliminary estimates of AJF technical potential in Hawaii based on previously developed GIS information layers.

Major Accomplishments

The GIS based analysis of AJF production potential is ongoing. The assessment of potential lands meeting requirements for land capability class, slope, and land use zoning was completed. The EcoCrop model is being implemented to predict yield as a function of the minimum mean monthly temperature and the annual rainfall. This will allow prescription of potential AJF feedstock crops on land areas capable of supporting their production under both rain-fed and irrigated conditions. This analysis will provide information necessary in determining cropping patterns and assessing transport costs to processing facility locations. The EcoCrop model's prediction of sugarcane potential was determined and the results were compared with historic sugarcane acreage, both rainfed and irrigated. EcoCrop's upper and lower values for temperature and rainfall that support optimal sugarcane production were varied to calibrate the prediction against historic acreage. The difference between the EcoCrop values and those representative of Hawaii conditions can be attributed to improvements due to plant breeding and unique combinations of environmental conditions. An example of the latter is the relatively young volcanic soils present in high rainfall areas on the island of Hawaii that allow for high drainage rates and accommodate sugar production. Similar analysis has begun with for *Eucalyptus grandis* and *Eucalyptus saligna*, the former suited for planting at lower, warmer, wetter locations and the latter better suited for cooler, drying sites.

Calibration of the EcoCrop model using historic sugarcane planted acreages was completed in 2018. This effort used a confusion matrix approach to validation (resulting in a Kappa value >0.4) and identified the annual mean temperature as being a better indicator of environmental capability than the minimum mean monthly temperature recommended by the EcoCrop developers. This effort highlights the need to adapt models to local conditions. Comparison of the model predictions for suitable cropping with current land uses is also being conducted to provide another indicator of agreement.

Dr. Curtis Daehler of the University of Hawaii, Department of Botany, completed a report assessing the invasiveness of pongamia. Retrospective analyses show that predictive weed risk assessment (WRA) systems correctly identify many major pest plants, but WRA predictions are not 100% accurate. The purpose of this study was to make field observations of pongamia planted around Oahu in order to look for direct evidence that pongamia is escaping from plantings and becoming an invasive weed on Oahu. Seven field sites were visited in varying environments across Oahu. Although some

pongamia seedlings were found in the vicinity of some pongamia plantings, particularly in wetter, partly shaded environments, almost all observed seedlings were restricted to areas directly beneath the canopy of mother trees. This finding suggests a lack of effective seed dispersal away from pongamia plantings. Based on its current behavior in the field, pongamia is not invasive or established outside of cultivation on Oahu. Because of its limited seed dispersal and low rates of seedling establishment beyond the canopy, risk of pongamia becoming invasive can be mitigated through monitoring and targeted control of any rare escapes in the vicinity of plantings. Seeds and seed pods are water dispersed, so future risks of pongamia escape and unwanted spread would be minimized by avoiding planting at sites near flowing water, near areas exposed to tides, or on or near steep slopes. Vegetative spread by root suckers was not observed around plantings on Oahu, but based on reports from elsewhere, monitoring for vegetative spread around plantations is recommended; unwanted vegetative spread might become a concern in the future that could be addressed with localized mechanical or chemical control.

Pods, oil seed cake, and oil were evaluated from a number of trees growing on the island of Oahu. Fundamental measurements of chemical composition were made for seeds, pods, extracted oil, and post-extraction seed material. Measured values included C, H, N, S elemental composition; energy content; volatile matter, fixed carbon, and ash content; and trace element composition. Oils were characterized for peroxide value, iodine value, fatty acid profile, free fatty acid content, flash point, density, viscosity, and phase transition temperatures. Development of coproducts from the pods and oil seed cake will be explored.

Publications
None

Outreach Efforts
Outreach in this task has focused on interactions with Terviva, a startup company that has identified pongamia germplasm production and marketing as the central focus of their business plan.

The PI and ASCENT collaborators from WSU and UT participated in a Bioeconomy Modelers Workshop organized by NREL.

Awards
None

Student Involvement
Three undergraduate student are involved in the project with primary responsibility for processing and analyzing samples of biomass materials selected for evaluation as potential alternative jet fuel feedstocks.

Plans for Next Period
The GIS analysis of AJF production potential will be completed to include State-wide working maps for each of the species will be developed and summarized in a report.

Analysis of coproduct development based on pongamia oil seeds and husks will be continued.

Task 0.4- Support of Indonesian Alternative Jet Fuel Supply Initiatives
University of Hawaii

Objective(s)
This task supports the Memorandum of Understanding between the Federal Aviation Administration (FAA) and Indonesian Directorate General of Civil Aviation (DGCA) to promote development and use of sustainable, alternative aviation fuels. Under the coordination of the FAA, efforts to establish points of contact and coordinate with Indonesian counterparts are ongoing.

Research Approach
This task will support the Memorandum of Understanding between the Federal Aviation Administration (FAA) and Indonesian Directorate General of Civil Aviation (DGCA) to promote development and use of sustainable, alternative

aviation fuels. This will begin with working with the FAA to establish points of contact to coordinate efforts with Indonesian counterparts. The Indonesian Aviation Biofuels and Renewable Energy Task Force (ABRETF) membership includes Universitas Indonesia, Institut Teknologi Bandung, and Universitas Padjadjaran. A prioritized list of tasks will be developed in consultation with Indonesian counterparts and data required to inform sustainability and supply analyses and potential sources of information will be identified. This could include data collection on Indonesian jet fuel use and resources for alternative jet fuel production, airport locations and annual and monthly jet fuel consumption patterns. Characterization of sustainable biomass resources with potential for use in producing alternative jet fuel supplies could include developing preliminary GIS mapping information of their locations and distributions and preliminary estimates of their technical potentials.

Milestone(s)

- Identify points of contact at Indonesian universities participating in ABRETF.
- Identify research needs and develop project plan.
- Develop data on potential project.

Major Accomplishments

The PI travelled to Jakarta in the first week of August 2017 and met with the following individuals:

- Cesar Velarde Catolfi-Salvoni (ICAO)
- Wendy Aritenang (ICAO)
- Dr. Ridwan Rachmat (Head of Research Collaboration, Indonesian Agency for Agricultural Research and Development)
- Sylvia Ayu Bethari (Head of Aviation Fuel Physical & Chemical Laboratory, Research and Development Centre for Oil and Gas Technology)
- Dr. Ina Winarni (Forest Product Research and Development Center, Ministry of Environment and Forestry)
- Dr. SD Sumbogo Murti (Center of Technology Energy Resources and Chemical Industry, Agency for the Assessment and Application of Technology)

The activities of the tropical supply chain analysis effort were presented to the group followed by a general discussion. The conclusion from this introductory meeting was that the Indonesian counterparts would seek agreement on how to move forward with future cooperation.

Publications

None

Outreach Efforts

Outreach efforts by the PI are described in the Major Accomplishments section above.

The PI is scheduled to travel to Jakarta at the end of November 2018, and meet with Dr. Wendy Aritenang of the International Civilian Aviation Organization Jakarta office to discuss the current activities. The same trip will include meetings with Universitas Indonesia representatives to the Association of Asia Pacific Rim Universities to establish a Cluster on Renewable Energy under its auspices.

Awards

None

Student Involvement

None

Plans for Next Period

The PI will continue to develop the cooperative research agenda between UH and Indonesian universities through continued dialog with FAA, ICAO, and the Indonesian Directorate General of Civil Aviation.

Task 2.2- National Lipid Supply Availability Analysis

University of Hawaii

Objective(s)

Activities under this task will support ASCENT partners working on a national lipid supply availability analysis by sharing data on tropical oilseed availability developed under previous year's activities.

Research Approach

Activities under this task will support ASCENT partners working on a national lipid supply availability analysis by sharing data on tropical oilseed availability developed under previous year's activities. This support will include estimates of pongamia production capability in the State in addition to assessments of waste cooking oil and tallow.

Milestone(s)

Milestones will coincide with lead institution, WSU, schedule for the national lipid supply analysis.

Major Accomplishments

Additional seeds and pods were collected from the pongamia tree on the University of Hawaii campus, Foster Botanical Garden and the Ke`ehi Lagoon Beach Park. Large (tens of kg) quantities of material were acquired from TerViva's plantings on Oahu's north shore for use in oil evaluation. Two oil seed presses were acquired and safety documents were developed. Pods, oil seed cake, and oil were evaluated from a number of trees growing on the island of Oahu. Fundamental measurements of chemical composition were made for seeds, pods, extracted oil, and post-extraction seed material. Measured values included C, H, N, S elemental composition; energy content; volatile matter, fixed carbon, and ash content; and trace element composition. Oils were characterized for peroxide value, iodine value, fatty acid profile, free fatty acid content, flash point, density, viscosity, and phase transition temperatures. Development of coproducts from the pods and oil seed cake will be explored.

Publications

None

Outreach Efforts

The PI presented information about this task to stakeholders attending the Green Initiative for Fuels Transition Pacific and CAAFI Hawaii quarterly conference call on September 5, 2018.

Awards

None

Student Involvement

Three undergraduate student are involved in the project with primary responsibility for processing and analyzing samples of biomass materials selected for evaluation as potential alternative jet fuel feedstocks.

Plans for Next Period

Efforts in the next period will include conducting production estimates of oil seed crops in Hawaii and assessing waste oil supplies. Information will be provided to the lead institution, WSU.

Task 3.2- Hawaii Regional Project

University of Hawaii

Objective(s)

A supply chain based on fiber feedstocks transported to a conversion facility located at Campbell Industrial Park (CIP) on Oahu will be evaluated (Figure 1). CIP is the current site of two oil refineries. Construction and demolition (C&D) wood waste from PVT Landfill could be the primary source of feedstock. Other sources will be evaluated from elsewhere on Oahu and from outer islands, including MSW stream from outer islands and mining of current stocks of waste in place.

Waste streams and purpose grown crops form the basis for a hub and spoke supply system with the hub located on Oahu. Pipelines for jet fuel transport are in place from CIP to Daniel K. Inouye International Airport and adjacent Joint Base Pearl Harbor/Hickam. Other coproduct off-takers for alternative diesel fuel (ADF) include Hawaiian Electric Co. and several military bases (Schofield Barracks (~50 MW alternative fuel-capable power plant under development), Kaneohe Marine Corp Base, etc.). Hawaii Gas (local gas utility) is also seeking alternative sources of methane if methane or feedstock suitable for methane production is available as a coproduct. Hawaii Gas currently off takes feedstock (naphtha) from refinery.

Figure 1. Possible locations of value chain participants for fiber based AJF production facility located at Campbell Industrial Park, Oahu.

Research Approach

Task 3.2.G1. Analysis of feedstock-conversion pathway efficiency, product slate (including co-products), maturation

Building on activities from previous years, additional supporting analysis will be conducted for proposed supply chains in Hawaii, including:

- 3.2.G1.1 Assess feedstock suitability for conversion processes (characterization, conversion efficiencies, contaminants, etc.) [UH and WSU (Manuel Garcia-Perez)]
- 3.2.G1.2 Acquire data re. feedstock size reduction, particle size of materials, bulk densities [UH, WSU (Manuel Garcia-Perez)]
- 3.2.G1.3 Evaluate coproducts at every step of the supply chain. [A01 team]

Task 3.2.G2. Scoping of techno-economic analysis (TEA) issues
This task will determine the current TEA status of targeted AJF production technologies that use fiber feedstocks as production inputs. [UH, WSU (Manuel Garcia-Perez), Purdue (Wally Tyner)]

Task 3.2.G3. Screening level greenhouse gas (GHG) life cycle assessment (LCA)
This task will conduct screening level GHG LCA on the proposed target supply chains and AJF conversion technologies.

Sub-tasks:
- 3.2.G3.1 Assess MIT waste based GHG LCA tools in context of Hawaii application. [MIT (Mark Staples)]
- 3.2.G3.2 Assess requirements to link previously completed eucalyptus energy and GHG analysis to the edge of the plantation with available GHG LCA info for conversion technology options. [MIT (Mark Staples), UH]
- 3.2.G3.3 Identify and fill information/data gaps

Task 3.2.G4. Identification of supply chain participants/partners

Sub-tasks:
- 3.2.G4.1 Define C&D landfill case
- 3.2.G4.2 Identify eucalyptus in existing plantations – landowners, leaseholder/feedstock producer, harvesting contractor, trucking, etc. [UH]
- 3.2.G4.3 Define other feedstock systems as identified. [A01 Team]

Task 3.2.G5. Develop appropriate stakeholder engagement plan

Sub-tasks:
- 3.2.G5.1 Review stakeholder engagement methods and plans from past work to establish baseline methods [UH, WSU (Season Hoard)].
- 3.2.G5.2 Identify and update engagement strategies based on updated CAAM/Outreach support tool [UH, WSU (Season Hoard)]

Task 3.2.G6. Identify and engage stakeholders

Sub-tasks:
- 3.2.G6.1 Identify stakeholders along the value chain and create database based on value chain location. [UH]
- 3.2.G6.2 Conduct stakeholder meeting using instruments developed in Task 3.2G5. [UH, WSU (Season Hoard)]
- 3.2.G6.3 Analyze stakeholder response and feedback to process. [UH, WSU (Season Hoard)]

Task 3.2.G7. Acquire transportation network and other regional data needed for FTOT and other modeling efforts

Sub-tasks:
- 3.2.G7.1 Acquire necessary data to evaluate harbor capacities and current usage. [UH, Volpe (Kristin Lewis), WSU (Mike Wolcott)]
- 3.2.G7.2 Acquire data on interisland transport practices. [UH, Volpe (Kristin Lewis), WSU (Mike Wolcott)]

Task 3.2.G8. Evaluate infrastructure availability

Sub-tasks:
- 3.2.G8.1 Evaluate interisland shipping options and applicable regulation. [UH, Volpe (Kristin Lewis), WSU (Mike Wolcott)]
- 3.2.G8.2 Evaluate transport or conveyance options from conversion location to end user and applicable regulation. [UH, Volpe (Kristin Lewis), WSU (Mike Wolcott)]

Task 3.2.G9. Evaluate feedstock availability

Sub-tasks:
- 3.2.G9.1 Refine/groundtruth prior evaluations of options for purpose grown feedstock supply [UH]

3.2.G9.2 Conduct projections of C&D waste supply moving forward and mining of waste in place on Oahu, MSW and mining of waste in place on other islands [UH]

Task 3.2.G10. Develop regional proposal
This task will use the information collected in Tasks 3.2.G1 through 3.2.G9 to develop a regional project proposal.

Milestone(s)
One milestone is associated with each of the subtask activities identified in the research approach section above.

Major Accomplishments
Characteristics of the feedstock generated at the landfill is the first piece of information needed to provide a basis for the ensuing analysis. The feedstock received at the landfill is an inhomogeneous mixture of construction and demolition. PVT is currently also mining the waste-in-place from the existing landfill and processing it to produce a feedstock stream. Both sources of waste (material arriving in trucks and mined waste-in-place) produce feedstock with highly variable fuel properties. ASTM sampling methods for refuse derived fuels have been reviewed and adapted to the current circumstances. Samples of feedstock particles (≤6 inches) will be sampled from a drop point in a processing conveyor. Approximately 2 ft^3 will be acquired at a time and this volume will be reduced to particles ≤0.25 inches that can be further subdivided using a riffler. A final representative sample of one kg will be retained for analysis and archiving. Analysis will include ultimate analysis, proximate analysis, higher heating value, analysis of ash chemical composition, bulk density, ash deformation temperature. PVT Land Company and the University of Hawaii have signed an agreement allowing UH personnel to locate equipment at the landfill, to obtain samples from the feedstock processing line, and to preprocess the samples to a particle size suitable for further work in a laboratory environment. Equipment has been moved to the site and off-grid power has been located for operating equipment.

Publications
None

Outreach Efforts
A presentation outlining the project was made to stakeholders attending the Commercial Aviation Alternative Fuels Initiative Seminar on Alternatives to Petroleum Jet webinar on February 23, 2018.

The PI presented information about this task to stakeholders attending the Green Initiative for Fuels Transition Pacific and CAAFI Hawaii quarterly conference call on September 5, 2018.

Awards
None

Student Involvement
Two undergraduate students have been involved in the development of the sample preparation strategy.

Plans for Next Period

During the next period, activities will begin toward completing subtasks identified in the research approach section above. A postdoctoral fellow will begin work on this project on March 1, 2019. The table below includes plans for each task moving forward.

Task Identifier	Task Title	Activity Moving Forward
3.2.G1	Analysis of feedstock-conversion pathway efficiency, product slate (including co-products), maturation	This task is in progress and will continue into the coming year to provide time series data on feedstock properties and on specific types of feedstock materials, e.g. construction, demolition, "mined" material, etc. Property data will inform the other tasks.
3.2.G2	**Scoping of techno-economic analysis (TEA) issues**	Based on TEA previously conducted by ASCENT collaborators (Manuel Garcia-Perez, Wally Tyner), a list of data needs for conducting TEA will be assembled and data availability will be assessed.
3.2.G3	Screening level greenhouse gas (GHG) life cycle assessment (LCA)	Based on GHG analysis previously conducted by ASCENT collaborators (Mark Staples), a list of data needs for conducting GHG analysis of the project will be assembled and data availability will be assessed.
3.2.G4	Identification of supply chain participants/partners	The anchor supply chain participants have been identified, but potential participants needed to complete the supply chain will be identified.
3.2.G5	Develop appropriate stakeholder engagement plan	Based on the supply chain participants and the stakeholders identified in Task 3.2.G6, a stakeholder engagement plan will be drafted in cooperation with Season Hoard.
3.2.G6	Identify and engage stakeholders	Stakeholder lists from previous biomass energy planning efforts in Hawaii will be reviewed and revised as needed. Stakeholder engagement will ensue as Tasks 3.2.G1 to G4 results are developed.
3.2.G7	Acquire transportation network and other regional data needed for FTOT and other modeling efforts	In consultation with ASCENT partners Kristin Lewis and Mike Wolcott, contacts from the State of Hawaii, Department of Transportation, Harbors Division will be engaged to initiate data collection on pipeline use and interisland barge movement of fuels.
3.2.G8	Evaluate infrastructure availability	Based on information and data developed in 3.2.G7, availability of existing infrastructure and options to target infrastructure expansion will be developed
3.2.G9	Evaluate feedstock availability	Refinement and groundtruthing of purpose grown crops will be approached by identifying existing plantings of candidate crops in botanical gardens and experiment stations and assessing them in their environment. Opportunities to establish additional plantings will be identified. After reviewing solid waste management plans, meetings will be held with the Solid Waste Divisions in each County to explore options for waste diversion opportunities.