Project 093(C) Collaborative Research Network for Global Sustainable Aviation Fuel Supply Chain Development: Latin America and Caribbean Case

Washington State University

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- P.I.s: Manuel Garcia-Perez and Michael P. Wolcott
- FAA Award Number: 13-C-AJFE-WaSU-037
- Period of Performance: October 30, 2024, to October 30, 2025
- Tasks:
  1. Create working groups in each Latin America and Caribbean (LAC) country involved in this project
  2. Conduct the design and analysis of sustainable aviation fuel (SAF) supply chains in each of the LAC countries involved in this project
  3. Create training modules/courses and graduate programs to train students

Project Funding Level

This project has received so far $656,586 in Federal Aviation Administration (FAA) funding and $656,586 in matching funds to WSU. Faculty time for Michael Wolcott, Manuel Garcia-Perez, Erik Jessup, Allyson Beall King, and Hanwu Lei contributes to the cost share. WSU funding is reported for the reporting period.

Investigation Team

Washington State University

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Project Overview

SAFs offer the potential to reduce the net environmental impact of aviation-related emissions while enhancing United States (U.S.) energy security and diversifying energy supplies. As a result, these technologies are receiving considerable attention from policymakers, industry, and academia. Most importantly, SAF has been included in the International Civil Aviation Organization (ICAO)'s Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which aims to reduce carbon dioxide (CO_2) emissions of international aviation above 85% of year-2019 levels. Using SAF, aircraft operators can reduce their offsetting requirements using the reduced CORSIA values of CO_2 emissions from SAF using their well-to-wake lifecycle greenhouse gas (GHG) emissions (including credits for biogenic carbon emissions during combustion).

Significant progress has been made over the past decade in assessing the economic and environmental properties of SAFs. This includes studies that have fostered our general understanding of life cycle analysis (LCA) (e.g., Stratton et al., 2010). In addition, work has focused on the economic and environmental properties of specific pathways, including jet fuel produced from hydroprocessed esters and fatty acids (HEFA) (Pearlson et al., 2013; Olcay et al., 2013; Seber et al., 2014; Stratton et al., 2011), from Fischer-Tropsch (FT) pathways (Stratton et al., 2011; Suresh et al., 2018; Suresh, 2016), and from biomass-derived sugars using a variety of chemical and biological techniques (Bond et al., 2014; Staples et al., 2014; Winchester et al., 2015). Most recently, Monte Carlo approaches have been systematically introduced for quantifying uncertainty and stochasticity in LCA and techno-economic analysis (TEA) (Bann et al., 2017; Oriakhi, 2020; Sureshet al., 2018; Suresh, 2016; Yao et al., 2017).

A suite of decision-support tools for assessing SAF supply chains has been developed within ASCENT Project 001. These tools can be used to assess the economics of SAF production, the optimization of SAF supply chain logistics, and the configuration of supply chains to consider both the sale of the fuel commodity and the commensurate environmental benefits. This suite of tools has been widely applied within regions of the U.S. and has potential for use internationally. Of particular interest is understanding feedstock availability and financial considerations for delineating both the minimum selling price and capital investment requirements for SAF production in regions outside the U.S. This project has the potential to benefit our understanding of the worldwide production of SAF to inform ICAO.

ASCENT Project 001 has made progress in harmonizing TEAs across technology pathways and feedstock selections for both technical and financial assumptions. Five SAF production pathways have been completed and are publicly available TEAs: HEFA, alcohol to jet (ATJ), FT, pyrolysis, and catalytic hydro thermolysis (CH) (Brandt et al., 2021a, 2021b, 2021c, 2022a, 2022b). These TEAs have been used extensively in work within ASCENT and for ICAO Committee on Aviation Environmental Protection (CAEP) analyses. As part of the ICAO tasks, the TEAs were updated to allow for regional variables to be changed based on global location. These include local consumable prices such as feedstock and electricity, as well as equipment capital costs and labor. Location-specific financial assumptions, including tax rate, inflation rate, and terms of loans, are also customizable. With expertise from Latin American colleagues, these TEAs can be rapidly deployed for use in member countries.

The process for siting facilities consists of two steps: (1) generating an initial set of candidates, and (2) using mixed integer optimization to select facilities from the candidate locations. The candidate generation phase uses geospatial data to evaluate a location's compatibility with specific facility types. The optimization phase allows for the locations of facilities to be found that result in systemwide minimum costs for a specific set of variables, like fuel cost, tariffs, and feedstock availability. Batch processing allows for the rapid iteration of variables so that a supply chain's sensitivity can be evaluated in different scenarios. During the past decades, Latin America has grown its bioethanol and biodiesel production. Brazil, Argentina, and Colombia have the largest production of biofuel in the region (IEA, 2021). In addition, the LAC region is

classified as a high-potential area for producing energy crops (Acharya & Perez-Pena, 2020; Trindale et al., 2019). Currently, interest in the production and consumption of SAF has spiked in the region. Omega Green is the first renewable diesel and SAF project under construction in Paraguay, with Brazilian investment (ECB Group, 2021). The project started in 2023 and is still under construction. Legal framework and initiatives to produce or import SAF are being initiated in the Dominican Republic, Mexico, Costa Rica, and Colombia (Argus, 2021). LATAM, a South American airline with main hubs in Chile, Peru, Brazil, and Colombia, plans to use 5% SAF for its operations by 2030, favoring producers throughout South America (LATAM, 2022). To date, no comprehensive assessment exists of the potential for SAF production in Latin America.

During Year 2, our team focused on four countries in Latin America and the Caribbean: (1) Colombia, (2) Dominican Republic, (3) Ecuador and (4) Costa Rica. So far, we have conducted literature reviews on biomass and SAF-related publications and existing infrastructure for each of these four countries. The study of Colombia has been socialized with the Colombian stakeholders and is now published. We are now socializing our literature reviews with our stake holders from Ecuador and Dominican Republic. The literature review of Costa Rica is still under internal review. These literature reviews are being used as a supporting source of information to create the SAF roadmaps in these countries.

The overall objectives of this project are to: (1) create working groups in each of the LAC focus countries involved in this project that will work directly with the students on the development of SAF supply chains, (2) design and analyze SAF supply chains in the LAC region, and (3) create training modules, courses, and graduate programs to train students and stakeholders in Latin America and the Caribbean on the design and analysis of SAF production and supply chains.

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Task 1 - Create Working Groups in Each of the LAC Countries Involved in This Project

Washington State University

Objective

The objective of this task is to engage with stakeholders from Ecuador, Dominican Republic, Costa Rica, and Colombia.

Research Approach

Under Task 1, the team has been working with groups in each of the LAC countries involved in this project. For Colombia, Dominican Republic, and Ecuador, we took advantages of activities in these countries. Last year, we expanded our work to cover Costa Rica. A new graduate student from Costa Rica (Rayman Angulo Gutierrez) joined our research program in January 2025. We are in contact with stakeholders in all these countries.

Milestone

- Started work on this task in January 2023 and continued work through 2025.

Major Accomplishments

We are working with active working groups in Colombia, Dominican Republic, Ecuador, and Costa Rica. The first workshop was hosted by ASCENT Project 093 by WSU in Bogota, Colombia, on March 15, 2024, with 37 attendees with diverse and covered industries, universities, and the government. In 2024 and 2025, technical support was provided to the Colombian Civil Aviation Authority (Aerocivil) on the Colombian SAF round map. The group in the Dominican Republic is formed by academic partners coordinated by the Ministry of Higher Education and the existing SAF round table coordinated by (Instituto Dominicano de Aviacion Civil (IDAC). Students participated in the "Second meeting: Sustainable Aviation Fuels," organized by the IDAC. Raul Perez presented the preliminary results of the overview for this country. All the students presented preliminary results from a dynamic systems analysis of four SAF production pathways. Universities and

industries mainly form the working group from Ecuador. We are working to attract more industries (especially EP Petroecuador) and more government agencies. In the case of Costa Rica, we have made our first contacts and have recruited a graduate student to work on this project with their civil authority.

Publications
None.

Outreach Efforts
- Participated (Raul Perez, Marcela Valderrama, Paulina Echeverria, and Micaela Peralta) in the "Second meeting: Sustainable Aviation Fuels," organized by the Sustainable Development Directorate of the IDAC in March 2025. Raul Perez presented the preliminary results of the overview for this country. All the students presented the preliminary results of a dynamic systems analysis for four SAF production pathways.
- Participated (Manuel Garcia-Perez) in the Latin American and Caribbean Air Transport Association (ALTA) Fuel and Sustainability Conference organized in the Dominican Republic in March 2025.
- Participated (Marcela Valderrama, a student from Colombia) in the event "Impact of SAF in the Supply Chain of the Fuel" organized by the Civil Aeronautics of that country. The results of the "SAF production in Colombia: opportunities and challenges" and the ASCENT TEA were referenced in the study.
- Held meetings with experts and stakeholders in Colombia, Dominican Republic, and Ecuador to validate the system dynamics models.

Student Involvement
- Claudia Marcela Valderrama (Colombian) has supported the Colombian working group communications since January 2023.
- Raul Perez, a Dominican Republic student who started his graduate studies on January 1, 2024, has supported the Dominican Republic working group communications.
- Paulina Echeverria and Micaela Peralta, Ecuadorian students who started their graduate studies on January 1, 2024, are in contact with stakeholders in their countries.

Plans for Next Period
- Continue supporting our stakeholders and participating in conferences that are relevant to them.

Task 2 - Conduct the Design and Analysis of SAF Supply Chains in Each of the LAC Countries Involved in the Project
Washington State University

Objective
The objective of this task is to develop system dynamic models to study the potential to produce SAF via HEFA, ATJ, municipal solid waste to SAF and energy crops to jet. These models will be used to study the number of plants that can be built in the Dominican Republic, Costa Rica, Ecuador, and Colombia, depending on the level of incentives. Once the number of plants has been identified, we will use Freight and Fuel Transportation Optimization (FTOT) to identify the optimal location.

Research Approach
Under Task 2, we conduct the design and analysis of SAF supply chains in each of the focus countries in LAC. In these studies, we will try to answer the following questions: (1) what LCA values for the feedstock and sustainability criteria compliance should be used, (2) what public policies the countries should develop to grow the production of SAF in Latin America, and (3) how should the design supply chain and sitting of facilities be conducted.

Milestone
- Started this task in January 2023 and continued working on this task through 2025.

Major Accomplishments

The students, Raul Perez, Paulina Echeverria, and Micalea Peralta, have completed writing the reports for the Dominican Republic and Ecuador; both documents are under review for publication in the WSU repository. The first draft of the Dominican Republic report was shared with stakeholders in March 2025. The Ecuadorian first draft report has been completed. The student, Rayman Angulo, has completed writing the report for Costa Rica, and the first draft has been shared with stakeholders in October 2025.

All the students are now developing system dynamics models to describe the effect of incentives on the number of HEFA, ATJ, pyrolysis, and gasification/FT fuel plants in the region. Students have presented the base case system dynamics models for the four main pathways: ATJ using sugarcane-derived ethanol, HEFA using used cooking oil and palm oil, FT using municipal solid waste, and pyrolysis of energy crops, as work in progress in the 2025 International System Dynamics Conference in Boston, Massachusetts. Four papers are currently in preparation, each focusing on the system dynamics base case for one of the four technologies being evaluated for SAF production. These papers will present the general modeling frameworks developed for each technology and explore a series of "what-if" scenarios to assess their performance, interactions, and potential contributions to the overall SAF production system. Two papers have been completed, one for the ATJ pathway and the other for the HEFA pathway and are now under review.

An econometric model has been developed to evaluate the impact of SAF prices on airfare and passenger demand, based on data from Colombia, Costa Rica, Dominican Republic, and Ecuador to the U.S., including ticket prices, fuel consumption, fuel prices, occupancy rates, load factors, and tourism statistics.

Volpe started to work with our Colombian partners, introducing the road network and running an initial proof of concept for the biodiesel supply chain. The biodiesel supply chain includes crude palm oil extraction, biodiesel production, and truck distribution to the main blending facilities listed by the Energy and Mines Ministry. Information regarding pipelines was provided to Volpe so they could initiate runs focused on SAF scenarios. The base cases of the FTOT tool are currently being tested for the HEFA and ATJ technologies in Colombia, Dominican Republic, and Ecuador, respectively.

Publications

Written Report

Martinez-Valencia, L., & Valderrama-Rios, C. (2024). *Sustainable Aviation Fuel Production in Colombia: Opportunities and Challenges*. Washington State University. https://doi.org/https://doi.org/10.7273/000006281

Outreach Efforts

We are working with Volpe to implement a FTOT proof of concept, focusing first on a road-only network. This model maps Colombia's road system, mills, biorefineries, and blending sites for the palm oil biodiesel supply chain.

Continuous meetings with experts and stakeholders in Colombia, the Dominican Republic, and Ecuador have been held to validate the system dynamics models.

- Meeting with Jairo Alfonso Cordero, Consultant, Government of Colombia, June 17, 2025
- Meeting with Juan Japa, Farmer, Sugarcane Industry, Dominican Republic, June 25, 2025
- Meeting with Monica Cuellar, New Business Manager, Fedepalma Colombia, July 1 & August 21, 2025
- Meeting with Carlos León, Manager, APALE Ecuador, July 8 & August 22, 2025
- Meeting with José Nuñez, Consultant, Government of the Dominican Republic, July 3, 2025
- Meeting with Professors, Universidad San Francisco de Quito, Ecuador, August 20, 2025
- Meeting with Rodrigo Gallegos, Executive Director, Aprograsec Ecuador, August 20, 2025
- Meeting with Yessica Castro, Daniel Galván, and Juan Japa, Experts, Government, and Academia, Dominican Republic, August 28, 2025
- Meeting with Jairo Salcedo, External Consultant, BioD Colombia, September 15, 2025

Awards

None.

Student Involvement

Claudia Marcela Valderrama (Colombia) is working on this task. Paulina Echeverria Paredes (Ecuador), Micaela Peralta (Ecuador), and Raul Perez Mena (Dominican Republic) started their graduate studies on January 1, 2024. Rayman Angulo (Costa Rica) started the PhD program in January 2025.

Plans for Next Period

- Continue working with Volpe to refine the base case scenario for the supply chain in Colombia using FTOT, focusing on optimizing the existing biodiesel supply chain, including biodiesel conversion and blending facilities.
- Continue to develop System Dynamics models for the main SAF technologies and use FTOT for each country, which will be used in the analysis of the potential to grow the industry in the different regions.
- Complete a final report for the Dominican Republic and a revised version of the report on the Ecuadorian Overview to be socialized with our stakeholders.

Task 3 - Creating Training Modules, a Course, and Graduate Programs for Training Students

Washington State University

Objective

The objective of this task is to create a year-long training program to introduce the stakeholders to the design of SAF supply chain, as well as a master's program.

Research Approach

Under Task 3, the team created training modules, a course, and graduate programs for the preparation of personnel involved in the design of SAF production supply chains. The training started with students from Latin America. The methodologies and tools developed as part of ASCENT Project 001 that are being used in the design of supply chains in the U.S. are being used to do similar work in Latin America. Our training materials included: (1) methodologies for the creation of waste biomass feedstock databases, geographic information systems (GIS), and facility siting (leaders: Michael Wolcott, Dane Camenzind, and Kristin Lewis); (2) supply chain configurations to capitalize on sale of the fuel commodity and valorizing environmental services (leaders: Lina Martinez, Michael Wolcott, Allyson Beall King); (3) logistics optimization (leaders: Eric Jessup, Dane Camenzind); and (4) SAF production technologies (mass and energy Balances [Aspen], TEA, and LCA) (leaders: Kristin Brandt, Manuel Garcia-Perez, Hanwu Lei). These training materials evolved into courses that will be offered as part of certificates and a master's program currently under review by the WSU faculty senate (Hanwu Lei).

Milestone

- Started work on this task in January 2023 and continued work through 2025.

Major Accomplishments

We made progress in the professional master's program and associated courses. The WSU Department of Biological Systems Engineering submitted the curriculum design for a master's program in sustainable aviation fuel production to the WSU Faculty Senate. To complete this program, students must complete two common classes, seven courses, and a capstone project. The common courses are: Sustainable Aviation Fuels Technology, Feedstock Assessment, and SAF Law, Policies, and Regulations. Students can obtain three certificates that, when combined, result in a master's degree. The first certificate, in SAF production technologies, comprises three courses: Biomass Conversion Technologies, SAF TEA, and Financing and Investment in Renewable Electricity and Hydrogen. The second certificate, in SAF law, policies, and systems view, includes three courses: LCA, Supply Chain Analysis and Optimization, and Systems Dynamics. The final certificate, in SAF fuel qualification, consists of two courses. This will be the first professional master program in the world and will start in September 2026. The first two courses for the master's program have been developed. Students collaborated to prepare the material and information for the SAF 501 Biomass Conversion Technologies and SAF 502 Sustainable Aviation Fuels Technology courses.

Publications
None.

Outreach Efforts
The master's program offer has been socialized with partners in Latin America.

Student Involvement
Claudia Marcela Valderrama, Raul Perez, Paulina Echeverria, Micaela Peralta, and Rayman Angulo were invited to participate in the development of the master's program.

Plans for Next Period
- Hold additional workshops with international organizations to enhance stakeholder engagement in Colombia, the Dominican Republic, Costa Rica, and Ecuador.
- Continue working with the WSU Senate to secure approval for our master's program and to develop new courses, aiming to start in September 2026.