

Project 080 Hydrogen and Power-to-Liquid Concepts for Sustainable Aviation Fuel Production

Washington State University
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University Participants

Washington State University (WSU)

- P.I.s: Manuel Garcia-Perez, Michael P. Wolcott
- FAA Award Number: 13-C-AJFE-WaSU-031
- Period of Performance: October 1, 2021 to September 30, 2022
- Tasks:
 1. Evaluate the strengths and weaknesses of hydrogen production and power-to-liquid (PtL) concepts.
 2. Assess how hydrogen production and PtL production can be integrated with existing production and distribution infrastructure (existing infrastructure and sustainable aviation fuel [SAF] technologies) to produce fuels with lower carbon intensity.

3. Synthesize the information and obtain rules on combining carbon, hydrogen, and energy sources with different conversion technologies to improve environmental impacts and costs.

Massachusetts Institute of Technology

- P.I.: Professor Steven R. H. Barrett
- FAA Award Number: 13-C-AJFE-MIT, Amendment Nos. 091 and 101
- Period of Performance: October 1, 2021 to September 19, 2023
- Tasks during current reporting period (October 1, 2021 to September 30, 2022):
 1. Develop methods for assessing the economic and environmental impacts of promising SAF production pathways.
 2. Apply models to analyze the economic and environmental footprint of SAF production pathways.
 3. Analyze the prospects of direct air capture (DAC) of atmospheric CO₂ to provide a carbon source for SAF production.

Project Funding Level

Washington State University

\$450,000 in FAA funding and \$450,000 in matching funds. State-committed graduate school contributions for Ph.D. students. Faculty time for Michael Wolcott, Manuel Garcia-Perez, Xiao Zhang, and Su Ha contribute to the cost share. WSU funding is reported for the reporting period.

Massachusetts Institute of Technology

\$450,000 in FAA funding and \$450,000 in matching funds. Sources of matching are approximately \$136,000 from MIT, plus third-party in-kind contributions of \$101,000 from Savion Aerospace Corporation and \$213,000 from NuFuels, LLC. MIT funding is reported for the period of performance indicated above.

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P.I.s:

Manuel Garcia-Perez, WSU (Tasks 1, 2, 3, and 6)
 Michael Wolcott, WSU (Tasks 1, 2, 3, and 6)
 Steven Barrett, MIT (Tasks 4, 5, 6, and 7)

Co-P.I.s:

Xiao Zhang, WSU (Tasks 1, 2, 3, and 6)
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 Jonathan Male, WSU (Tasks 1, 2, 3, and 6)
 Florian Allroggen, MIT (Tasks 4, 5, 6, and 7)

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Christoph Falter, MIT, Postdoctoral Associate (Tasks 4 and 5)
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Collaborating Researchers

- Corinne Drennan, Pacific Northwest National Laboratory (PNNL)

Project Overview

The aviation industry is under pressure to reduce its greenhouse gas (GHG) emissions. SAFs are considered the most promising approach for achieving the sector's GHG emission targets. To date, no comprehensive assessment exists for analyzing how different carbon, hydrogen, and energy sources can be combined with different conversion processes to produce SAF with high GHG emission reductions and low costs. The goals of this project are (a) to evaluate the strengths and weaknesses of hydrogen production and PtL concepts, (b) to assess the state of the art for the integration of hydrogen production, different carbon sources (including atmospheric CO₂ capture), and PtL production with existing infrastructure (SAF production and industries), (c) to analyze the cost and environmental impacts of these production pathways, and (d) to

synthesize this information and obtain rules on how to best combine carbon, hydrogen, and energy sources with different conversion technologies to improve environmental impacts and costs. This research will enable the identification of new pathways to optimize SAF production for maximum GHG reductions with minimal fuel costs.

Approved SAF pathways commonly use photosynthesis-derived carbon from sugars, lignocellulosic materials, or lipids. Some SAF technologies that are currently being investigated include those based on hydro-processed ester and fatty acid synthetic paraffinic kerosene (HEFA-SPK), Fischer-Tropsch synthetic paraffinic kerosene (FT-SPK), Fischer-Tropsch synthetic kerosene with aromatics (FT-SKA), synthesized iso-paraffins (SIP), Virent's BioForming synthesized aromatic kerosene, hydrodeoxygenation synthesized kerosene, catalytic hydro-thermolysis, alcohol-to-jet (ATJ) fuel, hydropyrolysis (Shell IH2), fast pyrolysis, and hydro-processed depolymerized cellulosic jet fuel. The jet fuels produced from seven paths (FT-SPK, HEFA-SPK, SIP, FT-SKA, ATJ, catalytic hydro-thermolysis, and HEFA) and by co-processing lipids and FT biocrude in refineries are now approved by the American Society for Testing Materials for use in commercial aircraft. Although these processes can result in substantial GHG reductions, their production costs are still substantially higher than those of conventional jet fuels derived from petroleum distillation (\$0.88–\$3.86 per liter) (Tanzil et al., 2021).

Previous studies (Tanzil et al., 2021) have shown that the quality of the carbon source determines the yield of SAF. For example, although lignocellulosic materials are 10 times cheaper than lipids (on a mass basis), the quality of the carbon source makes fuels derived from triglycerides much cheaper (2–5 times) than those derived from cellulose, hemicellulose, or lignin. Carbon in organic matrices containing a higher content of oxygen, nitrogen, and sulfur is more challenging to convert to jet fuel because of the penalties associated with the removal of oxygen, nitrogen, and sulfur, which typically consumes hydrogen. These contaminants can reduce the time between regeneration and the overall lifetime of the hydrotreating catalyst. Carbon in polymeric molecules is also more challenging to convert to jet fuel because it requires costly molecular weight reduction technologies and often lacks selectivity to the targeted jet fuel cut. Carbon in the form of aliphatic molecules can be more easily converted to jet fuel than carbon as aromatics. Carbon sources such as CO₂, biomass, coal, petroleum, and municipal solid waste (MSW) must be thoroughly investigated as feedstocks for SAF production. Because carbon is the highest-weight element in jet fuel production, high fuel yields can only be achieved in processes with high carbon conversion efficiencies.

Most technologies that produce SAF require high amounts of hydrogen, with 1 equivalent of hydrogen per fuel molecule on the low end (ATJ) and 6–8 moles of hydrogen per fuel molecule on the high end. Although hydrogen can currently be produced by many pathways using low-carbon-intensity electrons produced by wind and solar farms, current hydrogen production is mainly based on steam methane reforming (SMR), which is associated with significant CO₂ emissions. Commonly considered paths for hydrogen production include (a) steam and dry reforming of hydrocarbons, (b) water electrolysis, (c) plasma arc decomposition, (d) water thermolysis, (e) thermochemical water splitting, (f) thermochemical conversion of biomass (biomass gasification and biofuel reforming), (g) photovoltaic electrolysis, photocatalysis, and photochemical methods, (h) dark fermentation, (i) high-temperature electrolysis, (j) hybrid thermochemical cycles, (k) coal and petroleum gasification, (l) MSW gasification, (m) fossil fuel reforming, (n) biophotolysis and photo-fermentation, (o) artificial photosynthesis, and (p) photo-electrolysis (Dincer & Acar, 2015). One goal of this project is to evaluate the strengths and weaknesses of hydrogen production concepts, determine how they can be integrated with existing infrastructure to produce cheap green hydrogen, and identify the potential impact of these technologies in producing SAF.

In some biomass and waste conversion processes, carbon dioxide and methane are produced as a side product or as the starting material. To meet the specifications for liquid SAF, hydrogen will be needed to hydrogenate alkenes and hydrotreat oxygenates. Utilizing waste carbon oxides and methane can increase the amount of carbon obtained from resources in the SAF while reducing emissions. This can be done in conjunction with hydrogen production with a lower carbon intensity. A systematic analysis will examine the trade-offs between enhanced carbon utilization, the effects of increased amounts of renewable energy, the need for stability in the grid and energy storage, access to lower-carbon-intensity hydrogen against positive impacts on environmental indicators, the cost impact of such changes, and technology uncertainty in emerging science and engineering.

Over the past decade, significant progress has been made in assessing the economic and environmental properties of SAF. This work includes studies that have fostered our understanding of lifecycle analysis (LCA) in general (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 HEFA (Stratton et al., 2011; Pearlson et al., 2013; Olcay et al., 2013; Seber et al., 2014), from FT pathways (Stratton et al., 2011; Suresh, 2016; Suresh, 2018), 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; Suresh, 2016; Yao et al., 2017; Suresh, 2018; Oriakhi, 2020).

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Task 1 - Evaluate the Strengths and Weaknesses of Hydrogen and PtL Concepts in the United States

Washington State University

Objectives

The objective of Task 1 is to perform a literature review and develop design cases for hydrogen and PtL concepts.

Research Approach

In this task, we will identify areas that require more research and development to reduce technology uncertainty. Specifically, we analyze six technologies for hydrogen production: (a) steam reforming, (b) dry reforming, (c) water electrolysis, (d) gasification of carbonaceous materials (biomass, coal, bitumen, and MSW) (with steam and CO₂), (e) thermal decomposition of hydrocarbons (methane pyrolysis with capture and use of solid carbon), and (f) fossil fuel reforming. This task is being conducted by WSU and PNNL and started during Year 1. The main goal of this task is to build design cases for each of these hydrogen production technologies (mass and energy balances and TEAs) and identify the strengths and weaknesses of each technology studied. A team of hydrogen production experts from WSU and PNNL meets weekly with a Ph.D. student and post-doctoral associate from WSU to guide them in the literature review and in the creation of a road map for constructing design cases and identifying the opportunities and challenges for each of the technologies studied.

Milestones

In this first year, we started to work in two main areas: (a) a literature review of hydrogen production technologies within the context of SAF production and (b) mass and energy balances and TEAs of standalone hydrogen production technologies. We have written the first draft of a literature review for hydrogen production within the context of SAF technologies. Several standardized TEAs of hydrogen production technologies have been developed. We have calculated the minimum selling price and GHG footprint for each hydrogen production technology. The standardized TEAs are now available for team members to use.

Major Accomplishments

We have completed the first draft of a literature review on the TEAs of hydrogen production technologies (slow and high-pressure gasification, steam reforming, partial oxidation, autothermal oxidation, methane pyrolysis, and low- and high-temperature water electrolysis) and have identified several promising pathways in which hydrogen production technologies are integrated with gasification. We have also developed standardized design cases to estimate hydrogen production costs for each of the technologies studied.

Publications

Sierra V, Wolcott M, Zhang X, Ha S, Male J, Garcia A, Brand K, Garcia-Perez M, Drennan C, Holladay J: Emerging and Commercial Hydrogen Production Technologies for SAF Manufacturing: A comparative Literature Review. *Under internal review*.

Garcia-Perez, M., Garcia, A., Wolcott, M. (2022, October 24-27). *Production of cheap Sustainable Aviation Fuels (SAFs): Balancing Economic and Environmental Advantages*. Sustainable Energy for a Sustainable Future, San Pedro, San Jose.

Outreach Efforts

We presented our preliminary results at the ASCENT meeting on April 5-6, 2022, at the November 25-26, 2022 meeting, and at the Civil Aviation Alternative Fuels Initiative meeting on June 1-3, 2022 in Washington, DC.

Student Involvement

Valentina Sierra is working on the literature of hydrogen production technologies and the role hydrogen has on SAF production.

Plans for Next Period

We plan to submit the revised literature review and improve the design cases. In the next year, we will continue with our biweekly meetings with the panel of experts from PNNL to identify the strengths and weaknesses of new concepts for SAF production. We will discuss the integration of hydrogen production and PtL concepts with biomass-based SAF production

technologies. Our graduate student and research associate make presentations every 15 days and, based on recommendations from the panel of experts, work for 15 days on a new presentation.

Task 2 - Assess how Hydrogen Production and PtL Production can be Integrated with Existing Production and Distribution Infrastructure (Existing Infrastructure and SAF Technologies) to Produce Fuels with Lower Carbon Intensity

Washington State University

Objective

The goal of Task 2 is to estimate cost reduction opportunities that would arise if emerging hydrogen production technologies were co-located with SAF production technologies and existing infrastructure.

Research Approach

For SAF technologies, we study how hydrogen is used in hydrotreatment steps. We conduct weekly meetings with WSU, PNNL experts, and our Ph.D. students to identify hydrogen production opportunities in existing industries (petroleum refineries, dams, metallurgical industry, etc.). Our main goal is to estimate cost reduction opportunities that would arise if some of the emerging hydrogen production technologies were co-located with some of these industries. In a separate subtask, we will evaluate the impact of each of the emerging hydrogen production technologies on existing or emerging SAF technologies, including those based on (a) HEFA, (b) Virent's BioForming synthesized aromatic kerosene, (c) ATJ fuel, (d) natural sugar to hydrocarbon (SIP), (e) fast pyrolysis and the GFT process, and (f) selective carbonization/CO₂ gasification/steam reforming/FT processes. For each case, we will consider lignocellulose or lipids as feedstocks. Hydrogen utilization for SAF production typically occurs in a hydrotreatment step that varies depending on the technology (Tanzil et al., 2021; Han et al., 2019). This step can proceed from a simple hydrogenation, hydrodeoxygenation, hydro-cracking, or all of them together, depending on the technology (Han et al., 2019). Especially troublesome is the hydrotreatment of oligomers and materials with a high tendency to form coke (Han et al., 2019). In this task, we will develop detailed phenomenological mathematical models for the hydrotreatment step of the HEFA and fast pyrolysis pathways, which the team will then use to study potential strategies to reduce hydrogen consumption during SAF production (Chen et al., 2019; Plazas-Gonzalez et al., 2018). This type of model requires a detailed description of the chemical composition of the feedstock, the reaction mechanism, and associated kinetics (Guitierrez-Antonio et al., 2018; Talib-Jarullah, 2011; Boesen et al., 2017; Jenistova et al., 2017; Tieuli et al., 2019; Hechemi and Murzin, 2018). The modeling work will complement studies in batch and continuous hydrotreatment reactors with different catalysts to validate the mathematical model. This work will be expanded in Year 3 to cover other technologies. This work is not funded as part of the current proposal. The task will start in the next reporting period.

Milestone

This task started in January 2023.

Major Accomplishments

This task started in January 2023.

Publications

None.

Outreach Efforts

None.

Awards

None.

Student Involvement

A new student (Anika Afrin) has been hired to work on this task. She began her graduate studies on January 1, 2022.

Plans for Next Period

In the next year, we will review the different hydrotreatment technologies associated with producing SAFs and the mathematical models used to describe the operation of these reactors.

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Task 3 - Integration of Alternative Hydrogen and Carbon Sources into Fuel Conversion Pathways

Washington State University

Objective

The objective of Task 3 is to identify new pathways to optimize SAF production for maximum GHG reductions with minimal fuel costs.

Research Approach

This task is being conducted in two steps. As the first step, the WSU-PNNL panel of experts is meeting weekly with the Ph.D. student to discuss the potential for combining the SAF pathways studied under Task 2 with alternative carbon sources (MSW,

sludges from wastewater treatment plants, CO₂). In the second step, we will evaluate the potential integration of these technologies with the new hydrogen production technologies discussed in Task 1. We will use the information collected to propose design and synthesis rules (diagrams) to help visualize how the source of carbon, hydrogen, and available energy and the type of conversion technology impact main environmental and economic sustainability indicators. We aim to use this exercise to identify better paths for SAF production.

Milestones

We are following a holistic path to identify desired production pathways. First, we correlated the minimum fuel selling price from 50 SAF TEAs with a straightforward model proposed by Lange et al. (2016). The model estimates the production SAF cost of product yield, feedstock, and other supplied costs, including Low Carbon Fuel Standards (LCFS) and Renewable Identification Number (RIN) support. Our analysis estimated an average production cost of \$272/ton of feedstock processed, which is consistent for the chemical industry. We then developed three purely stoichiometric mass balances to estimate the effect of deoxygenation method (oxygen removal as O₂, H₂O, or CO₂) on production cost. Although water deoxygenation proved to be most advantageous, all idealized models proved viable, ruling out stoichiometry alone as a limiting factor in fuel production. These simple models were also used to study the effect of oxygen addition, plastics, and carbon sequestration on the overall performance of these ideal technologies. In this way, the combustion requirements of gasification were also ruled out as a limiting factor. The team has begun to analyze biomass gasification technologies. We have concluded that existing technologies for the conversion of biomass into syngas are limited by very low carbon conversion efficiencies. To achieve carbon conversion efficiencies close to 100%, the introduction of outside hydrogen and energy is necessary. Additionally, close to one third of the syngas energy is lost when biomass is converted to SAF, presenting a limitation that must be addressed. Our group is working on the development of new technologies to address these issues.

Major Accomplishments

We have learned that the most critical factor governing production cost is fuel yield, which is directly related to carbon conversion efficiency. However, to maximize carbon conversion efficiency, it is critical to remove oxygen in the form of water by reacting it with hydrogen, which requires the introduction of hydrogen from outside the system. Currently, gasification is the leading technology for producing syngas as an intermediate. Current gasification systems must be optimized for maximum carbon conversion efficiency. An overall mass and energy balance shows that typical gasification systems are oxygen-, energy-, and hydrogen-deficient and that current designs sacrifice carbon efficiency to address the lack of energy and hydrogen. This issue can be addressed by augmenting hydrogen and energy from outside the system. Furthermore, the CO in syngas affords a C/O ratio that is much higher than the C/O ratio of biomass. Consequently, oxygen needs to be added to the system. Syngas also has an energy content higher than that of the fuel produced; therefore, nearly one third of the system's energy is released as heat. Heat integration is critical to maximizing the economic viability of technologies producing syngas as an intermediate. Because hydrogen must be produced externally to maximize fuel production yields, hydrogen production technologies and their potential synergisms with SAF production must be carefully studied to develop optimized systems. We have produced an Excel-based model that accounts for both stoichiometric and thermodynamic constraints in fuel production from biomass. This tool has not been utilized but could theoretically be updated and deployed for the testing of basic process optimization. We have placed our extended Lange model into a Python module that allows the calculation of economics for simple stoichiometric processes. We can easily extend this model to accept generalized user inputs, if needed for public outreach.

Publications

None.

Outreach Efforts

We have biweekly meetings with our panel of experts and have been advancing in progress toward the goals of this task. We have completed a literature review of hydrogen production technologies, their TEAs, and the synthesis of new SAF production pathways. Our project was presented at the Spring ASCENT meeting (April 5-7, 2022) and at the Civil Aviation Alternative Fuels Initiative meeting in Washington, DC (June 1-3, 2022). We also presented our work at the October 2022 Fuel Task Group meeting in Alexandria, VA.

Student Involvement

Valentina Sierra (student), Anika Afrin (student), Aidan Garcia (research associate) and Robert Macias (research associated).

Plans for Next Period

In this quarter, we hope to have enough information to complete TEAs of new SAF production concepts integrating biomass gasification with existing hydrogen production pathways. We plan to develop design cases for novel selective gasification processes.

References

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Task 4 - Develop Methods for Assessing the Economic and Environmental Impacts of the Most Promising Fuel Production Pathways

Massachusetts Institute of Technology

Objectives

Under Task 4, the MIT team aims to define a method for assessing the economic and environmental impacts of promising fuel production pathways, including those identified by the WSU team under Tasks 1–3. For this purpose, the team develops TEA and LCA models. The TEA model calculates the minimum selling price of a specific fuel, and the LCA model computes its lifecycle GHG emissions. Because the exact process layout and process characteristics (e.g., mass and energy balances, CapEx, OpEx) of novel fuel production pathways are subject to uncertainty, the modeling chain must be stochastic. This approach allows the uncertainty to be represented in input parameters, which will be propagated through the model to obtain insights into the range of economic and environmental impacts associated with fuels from novel fuel production pathways.

Research Approach

The models leverage prior work on stochastic techno-economic and lifecycle GHG emission assessments of SAF (e.g., Bann et al., 2017; Suresh et al., 2016; Oriakhi, 2020). These models will be adjusted to assess future fuel production pathways with novel layouts and increased uncertainties. In building the stochastic models, careful consideration is given to categorizing inputs as uncertain instead of variable. An uncertain variable is one for which available data are sparse or there is little understanding of what contributes to a spread in values. An uncertain variable is also an input that a biofuel facility cannot intentionally control. Priority was placed on analyzing uncertainty and including it in a Monte Carlo analysis. Variability refers to inherent heterogeneity in the outcomes for a specific variable. Variable outcomes can be intentionally controlled, e.g., by choosing a production location. Variable inputs are chosen for sensitivity studies, e.g., to assess the impact of the carbon intensity of electricity on the lifecycle emissions of a fuel. Figure 1 summarizes the categorization of inputs.

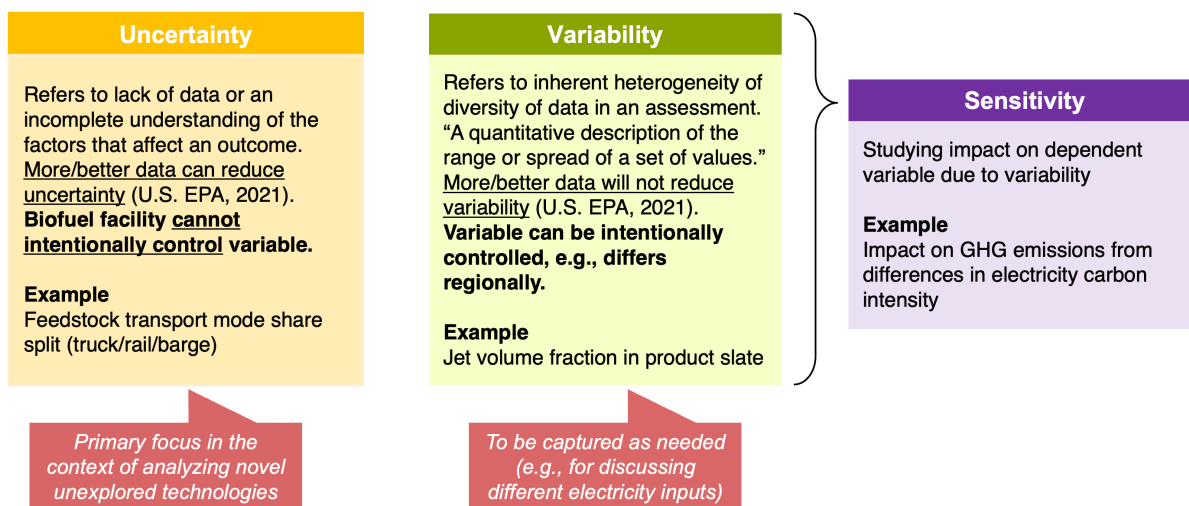


Figure 1. Input categorization as uncertainty, variability, and sensitivity. GFG: greenhouse gas.

Uncertain inputs are modeled as distributions for modeling. The LCA method follows the energy allocation method (Elgowainy et al., 2012). The TEA is implemented on the basis of the discounted cash flow rate of return (Pearlson et al., 2013). In the Monte Carlo analysis, random draws of uncertain variables are typically repeated 1,000 times. The number of runs is increased if the variance is determined to be higher than desired. This process is repeated for sensitivity studies as required.

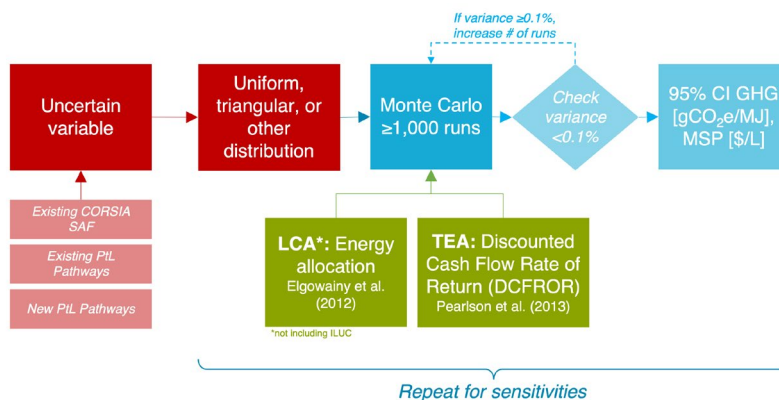


Figure 2. Modeling approach for Monte Carlo analysis for fuel lifecycle analysis (LCA) and techno-economic analysis (TEA). CI: carbon intensity; CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation; GHG: greenhouse gas; PtL: power to liquid; SAF: sustainable aviation fuel.

Milestone

The MIT team presented the initial modeling approach to the FAA and other stakeholders.

Major Accomplishments

The MIT team developed a first draft of the model structure, which can be applied to existing fuel pathways. This step will provide the basis for further model development, validation, and application.

Publications

None.

Outreach Efforts

- The team provided insights into the modeling approach during the Fall 2021 and Spring 2022 ASCENT meetings.
- The team presented this work to the Fuels Task Group in October 2022.

Student Involvement

During the reporting period, Tae Joong Park (MIT graduate student) was working this task.

Plans for Next Period

The team will continue to refine the method while rolling it out to numerous pathways (Task 5).

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Task 5 - Apply Models to Analyze the Economic and Environmental Footprint of SAF Production Pathways

Massachusetts Institute of Technology

Objective

Under Task 5, the MIT team aims to apply the models developed under Task 4 to provide harmonized assessments of the minimum selling price and lifecycle GHG emissions of different SAF pathways. During the reporting period, the team applied the modeling chain to analyze the economic and environmental implications of using renewable electricity and hydrogen from different sources in selected CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation)-eligible SAF pathways.

Research Approach

For the current reporting period, the MIT team analyzed the HEFA process with used cooking oil (UCO) feedstock. Existing literature sources (e.g., Seber et al., 2014; Lopez et al., 2010; Capaz et al., 2020; ICAO 2022) were used to populate distributions for uncertain parameters. Such uncertain parameters included transport distances for raw grease collection, rendered oil transport, natural gas and electricity use for UCO rendering and for fuel production, and process yields. Uniform distributions were fit to data whenever only low and high values were available. Triangular distributions were fit to inputs when a mean value and low and high values were available.

The Monte Carlo results shown in Figure 3 indicate that the uncertainty band (5th to 95th percentile spread) for the HEFA UCO base case (using hydrogen from SMR; gray line) is approximately 1.5 g CO₂e/MJ per unit SAF for U.S. grid electricity from the GREET 2019 model (Argonne National Laboratory, 2022). The team studied the sensitivity of the result with respect to electricity carbon intensity and found that the uncertainty band remains relatively small (gray line). This result arises because electricity accounts for ~5% of direct process energy in the HEFA process and the uncertainty in the electricity input is small. If the process is reconfigured to use hydrogen from electrolysis instead of SMR (green line), the sensitivity in fuel carbon intensity to the electricity carbon intensity increases significantly. For electricity inputs with a carbon intensity lower than 165 g CO₂e/kWh, the team found that the hydrogen supply from electrolysis produces a lower fuel carbon intensity than

when hydrogen from SMR is used. Electricity from solar power, wind, natural gas with carbon capture and sequestration, hydropower, and combined cycle combustion of willow are examples of electricity energy sources that would result in carbon savings.

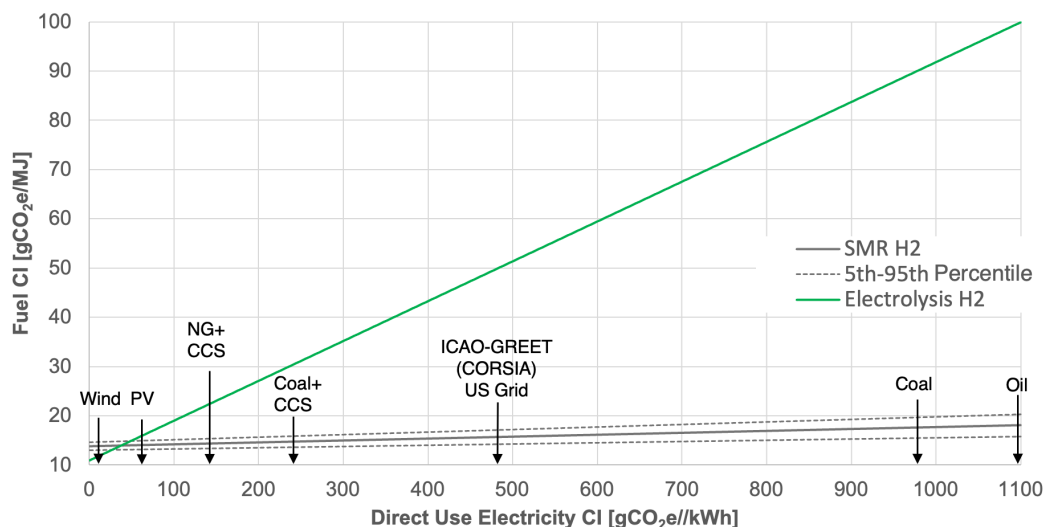


Figure 3. Sensitivity of carbon intensity (CI) for hydro-processed ester and fatty acid from used cooking oil fuel to the electricity CI for H₂ from steam methane reforming (SMR) and electrolysis. CCS: carbon capture and sequestration; NG: natural gas; PV: photovoltaic.

Milestone

The MIT team presented the initial modeling approach to the FAA and other stakeholders.

Major Accomplishments

The MIT team presented initial model results, which will provide the basis for further modification of the model.

Publications

None.

Outreach Efforts

- The team provided insights into the modeling approach during the Fall 2021 and Spring 2022 ASCENT meetings.
- The team presented this work to the Fuels Task Group in October 2022.

Student Involvement

During the reporting period, Tae Joong Park (MIT graduate student) worked this task.

Plans for Next Period

The team aims to roll out the model for additional CORSIA-eligible pathways. In addition, the team intends to start analyses on novel fuel pathways.

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Task 7 - Analyze the Prospects of DAC of Atmospheric CO₂ to Provide a Carbon Source for SAF Production

Massachusetts Institute of Technology

Objectives

Under Task 7, the MIT team aims to analyze proposed technological approaches for DAC as well as their readiness, scalability, and economic performance. Past and potential future trajectories of DAC technologies will be analyzed to define scenarios of how DAC could evolve to provide a potential carbon source for SAF production. In addition, the opportunity space for implementing different DAC technologies with conversion processes will be analyzed.

The initial step under this task was to provide an overview of the existing production technologies.

Research Approach

The team has focused on identifying different DAC technologies, their readiness, and potential development trajectories. This effort includes first-order stochastic assessments of economic performance for a range of technology scenarios. In addition to literature studies and detailed analyses of the different process steps, the team is conducting expert interviews.

Milestone

The MIT team ramped up work under this task in Fall 2022.

Publications

None.

Outreach Efforts

None.

Student Involvement

During the reporting period, Tara Housen (MIT graduate student) worked this task.

Plans for Next Period

The team will continue analyses of DAC processes, as described above.