Project 001(F) Alternative Jet Fuel Supply Chain Analysis

Massachusetts Institute of Technology

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- P.I.: Steven R. H. Barrett
- FAA Award Number: 13-C-AJFE-MIT, Amendment Nos. 003, 012, 016, 028, 033, 040, and 048
- Period of Performance: Aug. 1, 2014 to Aug. 31, 2019
- Tasks (note that the tasks listed here are relevant only to the reporting period, 10/01/2017 – 09/31/2018):
    1. Support U.S. participation in the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP) Alternative Fuels Task Force (AFTF) to appropriately account for the use of alternative jet fuels under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) by calculating default core life cycle greenhouse gas (GHG) emissions values;
    2. Support FAA work to calculate induced land use change (ILUC) emissions of alternative jet fuels, and assess sustainability certification schemes for potential inclusion under CORSIA;
    3. Comprehensively quantify and assess the impact of various policy options, in isolation and in combination, on the financial viability of alternative aviation fuel in order to provide policy guidance to States that are party to CORSIA;
    4. Collaborate with ASCENT Project 21 to capture the climate impacts of non-CO_2 life cycle emissions from petroleum and alternative aviation fuels in APMT-Impacts Climate;
    5. Collaborate with WSU to facilitate development of Aspen HEFA model;
    6. Provide additional (including in-person) support to FAA for decision-making in the context of AFTF.

Hasselt University (sub-award from MIT)

- P.I.(s): Steven R.H. Barrett, Professor
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2. Comprehensively quantify and assess the impact of various policy options, in isolation and in combination, on the financial viability of alternative aviation fuel in order to provide policy guidance to States that are party to CORSIA;
3. Provide additional (including in-person) support to FAA for decision-making in the context of AFTF.

Project Funding Level

$2,235,000 FAA funding and $2,235,000 matching funds. Sources of match are approximately $388,000 from MIT, plus 3rd-party in-kind contributions of $809,000 from Byogy Renewables, Inc. and $1,038,000 from Oliver Wyman Group.

Investigation Team

Principal Investigator:	Professor Steven Barrett (MIT)
Co-Principal Investigator:	Dr. Raymond Speth (MIT)
Co-Investigators:	Dr. Mark Staples, Dr. Florian Allroggen (MIT)
Graduate Research Assistants:	Timothy Galligan, Paula do Vale Pereira, Juju Wang, Uyiosa Oriakhi (MIT)

The research will partly be conducted through a sub-award with Hasselt University (Belgium), led by Prof. Robert Malina, and Hasselt University post-doctoral researcher Hakan Olcay.

Project Overview

The overall objectives of ASCENT Project 01, for the reporting period October 1, 2017 to September 30, 2018, were to:

- Derive information on regional supply chains to create scenarios for future alternative jet fuel (AJF) production;
- identify the key supply chain-related obstacles that must be overcome for commercial scale production of AJF in the near term;
- Achieve large-scale replacement of conventional jet fuel with AJF in the longer term.

Following these overall objectives, MIT's work under ASCENT Project 01 from 10/01/2017 to 09/31/2018, was focused on the following:

1. Support U.S. participation in ICAO CAEP AFTF to appropriately account for the use of alternative jet fuels under CORSIA by calculating default core lifecycle greenhouse gas (GHG) emissions values
2. Support FAA work to calculate ILUC emissions of alternative jet fuels, and assess sustainability certification schemes for potential inclusion under CORSIA
3. Comprehensively quantify and assess the impact of various policy options, in isolation and in combination, on the financial viability of alternative aviation fuel in order to provide policy guidance to States that are party to CORSIA;
4. Collaborate with the ASCENT Project 21 team to capture the climate impacts of non-CO_2 lifecycle emissions from petroleum and alternative aviation fuels in APMT-Impacts Climate;
5. Collaborate with Washington State University to facilitate development of an Aspen model of the hydroprocessed esters and fatty acids (HEFA) fuel production process
6. Provide additional (including in-person) support to FAA for decision-making in the context of AFTF.

Task 1- Default Core LCA Emissions Value Calculation and LCA Methodology Development for Use Under CORSIA

Massachusetts Institute of Technology

Objective(s)

The overall objective of this task is to provide support to the FAA for its engagement with ICAO CAEP AFTF, specifically on the development of the methodologies for appropriate accounting of AJF lifecycle GHG emissions under CORSIA, and applying the method to calculate AJF default core LCA (CLCA) emissions values for use under CORSIA.

Research Approach

Introduction

During this reporting period, significant progress was made on the work of the CLCA Task Group of AFTF. The MIT ASCENT Project 01 team has been key to this progress in terms of two primary tasks, calculation of default core LCA values for a number of pathways to be used under CORSIA and development of a method to account for avoided landfilling and recycling emissions associated with using municipal solid waste (MSW) as a feedstock for AJF production. These two items are described below.

Default core LCA calculation for CORSIA

During the reporting period, AFTF met three times: AFTF/05 from October 23-25, 2017 in Brasilia, Brasil; AFTF/06 from April 23-27, 2018 in Montreal, Canada; and AFTF/07 from September 17-21, 2018 in Montreal, Canada. In preparation for each meeting, MIT carried out LCA on a number of AJF pathways, in collaboration with researchers from the European Union Joint Research Center (JRC), Argonne National Laboratory (ANL), the University of Toronto, the Brazil Bioethanol Science and Technology Laboratory (CTBE) and Universidade Estadual de Campinas (Unicamp).

The pathways that MIT worked on in advance of each of these meetings, as well as the institutions with which MIT collaborated to verify the results, are shown in Table 1.

Table 1. Pathways for which MIT carried out default core LCA calculations during the reporting period, in the context of ICAO CAEP AFTF. The table indicates the meeting at which AFTF agreed upon the default core LCA values calculated by MIT, as well as the institutions with which MIT collaborated to verify the results presented.

Meeting	Pathway	Collaborating institutions
AFTF/05	Sugarcane SIP	JRC, Unicamp
	Sugarcane iBuOH ATJ	JRC, CTBE
AFTF/06	Corn grain EtOH ATJ	JRC
	Sugarcane EtOH ATJ	JRC, CTBE
AFTF/07	Corn grain iBuOH ATJ	JRC
	Herbaceous lignocellulosic iBuOH ATJ	JRC
	Molasses iBuOH ATJ	JRC
	Sugarbeet SIP	JRC

The GREET® (the Greenhouse gasses, Regulated Emissions, and Energy use in Transportation) (Argonne National Laboratory, 2015) model was used for the analyses by MIT. GREET is a peer-reviewed, publicly available, and editable software. JRC used the E3 Database model for their calculations (Ludwig-Bolkow Systemtechnik GMBH, 2006). Over the course of the analysis performed for AFTF, the original database was reviewed and updated to respond to AFTF-specific requirements. Lifecycle inventory datasets for the various AJF pathways were inputs for these LCA models, and were put together collaboratively based on information from experts from the difference institutions. These data are documented in detail in the following Information Papers presented to AFTF: CAEP/11-AFTF/5-IP/3; CAEP/11-AFTF/6-IP/6; and CAEP/11-AFTF/7-IP/11. The functional unit was defined as one mega joule (MJ) of delivered jet fuel energy (lower heating value), and the LCA results are presented in terms of the amount of GHG emissions for each functional unit (gCO_2e/MJ).

Previously, AFTF had agreed to a methodology for the calculation of default CLCA values. Because the development of this methodology was carried out in a previous reporting period, it is not discussed in detail here. However, some of the key facets of this methodology consist of the following:

- Core default LCA values are calculated at a global level of resolution
- A pathway is defined as a feedstock and conversion technology pairing for which emissions vary by <10% of the conventional jet fuel baseline (8.9 gCO_2e/MJ)

- Default values are calculated as the mid-point of the range of results for a given pathway

Default CLCA values calculated in advance of AFTF/05

Sugarcane SIP
The life cycle inventory (LCI) data for these pathways were brought forward by technical experts from MIT, JRC and Unicamp. The initial comparison of these three data sources revealed a number of differences in the core LCA results. One of the reasons for notable differences in the feedstock cultivation emissions was the assumed farnesene yields: MIT assumed 17% (wt.) yield of farnesene from sucrose, JRC assumed 13%, and the Unicamp analysis assumed higher farnesene yields and sugarcane quality (the exact values used in the Unicamp analysis could not be revealed due to their proprietary nature).

Following discussion amongst the experts from the three institutions, it was proposed to use harmonized MIT and JRC CLCA results, as shown in Table 2, to define the default CLCA value for the sugarcane SIP pathway. In addition, intra-continental transportation of the finished fuel product was assumed, in order to be consistent with the other pathways considered.

Table 2. Core LCA results used for sugarcane SIP default core LCA value calculation

Conversion technology	Data source	Model	Cultivation	Feedstock transp.	Fermentation and upgrading	Regional fuel transp.	Total emissions [gCO_2e/MJ]	Midpoint value [gCO_2e/MJ]
SIP	MIT	GREET	17.6	2.8	11.4	0.3	**32.1**	**32.8**
	JRC	E3db	20.9	1.9	10.4	0.3	**33.5**	

Sugarcane iBuOH ATJ
The LCI data for these pathways were brought forward by technical experts from MIT, JRC, and CTBE. All of these analyses considered isobutanol (iBuOH) as the intermediate alcohol, which is then dehydrated and oligomerized to jet fuel. To make a consistent comparison of CLCA results from these three data sources, it was proposed to harmonize the assumptions in three areas: the iBuOH transportation step was removed from the JRC results, and the jet fuel transportation emissions were assumed to be equivalent to those calculated for the sugarcane SIP pathway; the average of the jet fuel transportation emissions from the MIT and JRC results was applied to the CTBE results, in order to consistently approximate intra-continental fuel transportation emissions; and gaseous H_2 requirements from steam methane reforming from the MIT analysis was applied to the CTBE data, as modelled in GREET 2016.

The core LCA results from the three data sources, following the harmonization of these parameters, are shown in Table 3, which were to propose the default CLCA value for this pathway.

Table 3. Harmonized core LCA results for sugarcane ATJ default value calculation

Conversion technology	Data source	Model	Cultivation	Feedstock transp.	Fermentation and upgrading	Regional fuel transp.	Total emissions [gCO_2e/MJ]	Midpoint value [gCO_2e/MJ]
ATJ	MIT	GREET	12.4	1.9	6	0.3	**20.7**	**24.0**
	JRC	E3db	17.7	1.6	7.7	0.3	**27.3**	
	CTBE	GREET	13.1	1.7	6.7	0.3	**21.8**	

Default CLCA values calculated in advance of AFTF/06

Corn grain EtOH ATJ
The system boundary considered for this pathway includes corn grain cultivation and harvesting, transportation of the feedstock to a drop-in fuel production facility, fermentation to ethanol and upgrading to a drop-in fuel slate and finished jet fuel transportation and distribution. Two independent LCA sources for the corn grain EtOH AJT fuel pathway were compared:

an updated version of the pathway described in Staples et al. (2014) and modelled in GREET.net (v.1.3.0.13239) by MIT; and the same pathway as modelled by JRC in the E3db.

Table 4. Comparison of corn grain ethanol ATJ LCA data

Data source	Model	Cultivation and harvesting	Feedstock transp.	Fermentation and EtOH upgrading	Jet fuel transp.	Total emissions [gCO_2e/MJ]	Proposed default CLCA value [gCO_2e/MJ]
MIT	GREET	21.3	1.2	42.7	0.4	65.6	65.7
JRC	E3db	31.2	2.1	32.0	0.4	65.7	

The largest differences in the corn grain ethanol ATJ data from MIT and JRC were in the cultivation and harvesting, and fermentation and ethanol upgrading steps. Despite these differences, the overall LCA results from the two data sources were within 10% of the petroleum-derived jet fuel baseline (8.9 gCO_2e/MJ), and therefore these data were used to propose a default CLCA value for the pathway.

Sugarcane EtOH ATJ
The system boundary for the sugarcane EtOH ATJ pathway includes sugarcane cultivation and harvesting, transportation of the feedstock to a drop-in fuel production facility, fermentation to ethanol and upgrading to a drop-in fuel slate and finished jet fuel transportation and distribution. Three independent LCA sources for the sugarcane EtOH ATJ pathway were compared: an updated version of the pathway described in Staples et al. (2014) and modelled in GREET.net (v.1.3.0.13239) by MIT; the pathway as modelled by JRC in the E3db; a modified version of the pathway described in Bonomi et al. (2016), Chagas et al. (2016) and Klein et al. (2018) modelled by CTBE.

Table 5. Comparison of sugarcane ethanol ATJ LCA data

Data source	Model	Cultivation and harvesting	Feedstock transp.	Fermentation and EtOH upgrading	Jet fuel transp.	Total emissions [gCO_2e/MJ]	Proposed default CLCA value [gCO_2e/MJ]
MIT	GREET	13.7	1.6	4.6	0.4	20.4	24.1
JRC	E3db	17.5	1.6	7.7	0.4	27.2	
CTBE	ReCiPe	19.9	2.1	5.3	0.4*	27.7	

*Note that these emissions were not initially included in the CTBE data. Therefore, the value for jet fuel transportation emissions from the other data points were adopted to maintain consistency.

The largest differences in the sugarcane EtOH ATJ data were in the cultivation and harvesting step and fermentation and ethanol upgrading steps. Despite these differences, the overall LCA results from the two data sources were within 10% of the petroleum-derived jet fuel baseline (8.9 gCO_2e/MJ), and therefore this data was used to propose a default CLCA value for the pathway.

<u>Default CLCA values calculated in advance of AFTF/07</u>

Corn grain iBuOH ATJ
Two independent data sources were compared for the corn grain iBuOH ATJ pathway to determine an appropriate default CLCA value: one carried out by MIT using the GREET.net model (v.1.3.0.13239) and the other by JRC using the E3db. A comparison of the results from the MIT and JRC analyses are shown in Table 6. Despite some differences, the results from the two models are within the 8.9 gCO_2e/MJ definition of a pathway. Therefore, these data were used to propose a default CLCA value for the corn grain iBuOH ATJ pathway.

Table 6. Comparison of default core LCA results for corn grain iBuOH ATJ from MIT and JRC

Conversion technology	Data source	Model	Cultivation	Feedstock transp.	Fermentation and upgrading	Jet fuel transp	Total emissions [gCO_{2e}/MJ]	Proposed default CLCA value [gCO_{2e}/MJ]
Corn grain iBuOH ATJ	MIT	GREET	15.9	0.9	38.8	0.4	56.0	55.8
	JRC	E3db	22.5	0.6	32.1	0.3	55.5	

Herbaceous lignocellulosic energy crop iBuOH ATJ
Three independent analyses were compared for this pathway to determine an appropriate default CLCA value. MIT modelled the switchgrass and miscanthus iBuOH ATJ pathways in GREET.net (v.1.3.0.13239) and JRC independently modelled the switchgrass iBuOH ATJ pathway in the E3db. The LCA results from the MIT and JRC analyses are compared in Table 6. These results are within the 8.9 gCO_2e/MJ definition of a pathway, therefore the proposed default core LCA value for the herbaceous lignocellulosic iBuOH ATJ pathway was calculated using these data.

Table 7. Comparison of default core LCA results for herbaceous lignocellulosic iBuOH ATJ from MIT and JRC

Conversion technology	Data source	Model	Cultivation	Feedstock transp.	Fermentation and upgrading	Jet fuel transp	Total emissions [gCO_{2e}/MJ]	Proposed default CLCA value [gCO_{2e}/MJ]
Miscanthus iBuOH ATJ	MIT	GREET	12.5	1.4	27.7	0.4	42.1	43.4
Switchgrass iBuOH ATJ	MIT	GREET	14.9	2.1	27.0	0.4	44.5	
	JRC	E3db	9.9	3.1	31.4	0.3	44.7	

Molasses iBuOH ATJ
Two independent analyses were used to evaluate this pathway. The JRC analysis was carried out using the E3db, and assumed that this pathway was entirely consistent with the sugarcane iBuOH ATJ pathway for which default core LCA values have already been calculated. In contrast, the MIT analysis modelled a process of sugar extraction from sugarcane, in which molasses is a by-product. This was modelled in GREET.net model (v.1.3.0.13239). The results for the MIT analysis on the molasses iBuOH AJT pathway are shown below in Table 8, and are compared to the data proposed by JRC. These data are within the definition of a pathway of 8.9 gCO_2e/MJ, therefore these data were used to determine the default CLCA value for this pathway.

Table 8. Summary of core LCA results for the molasses iBuOH ATJ pathway

Conversion technology	Data source	Model	Cultivation	Feedstock transp.	Fermentation and upgrading	Jet fuel transp	Total emissions [gCO_{2e}/MJ]	Proposed default CLCA value [gCO_{2e}/MJ]
Molasses iBuOH ATJ	JRC	E3db	17.7	1.6	7.7	0.3	27.3	27.0
	MIT	GREET	17.8	2.1	6.4	0.3	26.6	

Sugarbeet SIP
The results for the JRC and MIT analyses of the sugarbeet SIP pathway, using the E3db and GREET.net (v.1.3.0.13239) models, respectively, are shown below in Table 9. A number of factors contribute to the discrepancy between the two independent studies. The two analyses rely on differing data sources for sugarbeet cultivation. MIT assumes a lower sugar yield from sugarbeet, resulting in a 21% lower energetic yield of farnesene per unit feedstock and there are differing assumptions around biogas yield from sugarbeet pulp and electricity and heat co-generation efficiencies. Despite the differing assumptions, these results were within the definition of a pathway for AFTF of 8.9 gCO_2e/MJ, therefore the proposed default core LCA value for the sugarbeet SIP pathway was evaluated using these data.

Table 9. Default core LCA results for sugarbeet SIP

Conversion technology	Data source	Model	Cultivation	Feedstock transp.	SIP production	Jet fuel transp	Total emissions [gCO_{2e}/MJ]	Proposed default CLCA value [gCO_{2e}/MJ]
SIP from sugarbeet	JRC	E3db	11.0	0.9	16.6	0.3	28.8	32.4
	MIT	GREET	23.4	1.4	10.8	0.4	36.0	

Summary of MIT work on default CLCA value calculations
All of the results and analyses summarized above, for which MIT carried out LCA analyses, were eventually accepted by AFTF, and are to be finalized by CAEP in February 2019. A summary of the agreed upon default CLCA values are given in Table 10. In addition, Prof. Robert Malina of Hasselt University (a sub-awardee under this project) led the AFTF CLCA Task Group during this reporting period.

Table 10. Summary of AFTF-agreed default CLCA values

Meeting	Pathway	Collaborating institutions	AFTF agreed default CLCA value [gCO_2e/MJ]
AFTF/05	Sugarcane SIP	JRC, Unicamp	32.8
	Sugarcane iBuOH ATJ	JRC, CTBE	24.0
AFTF/06	Corn grain EtOH ATJ	JRC	65.7
	Sugarcane EtOH ATJ	JRC, CTBE	24.1
AFTF/07	Corn grain iBuOH ATJ	JRC	55.8
	Herbaceous lignocellulosic iBuOH ATJ	JRC	43.4
	Molasses iBuOH ATJ	JRC	27.0
	Sugarbeet SIP	JRC	32.4

Methodology development for MSW emissions crediting

During this reporting period, Dr. Mark Staples from the MIT Project 01 team led an AFTF Small Group to define a methodology for estimating avoided landfilling and recycling emissions credits associated with using MSW as a feedstock for AJF production. The progress of this small group was presented to AFTF/06 and AFTF/07 and is documented in detail in CAEP/11-AFTF/6-IP/8 and CAEP/11-AFTF/7-IP/4.

This work resulted in the proposal of a landfill emissions crediting (LEC) methodology based on the first-order decay method and adopts elements of the UNFCCC Clean Development Method (CDM) for evaluating emissions avoided from landfilling. The recycling emissions credit method that was proposed is adopted from the UNFCCC CDM.

This work also assesses the risk of double counting emissions reductions associated with emissions credits and quantifies the impacts of options to mitigate the risk. The results show that, even using very conservative assumptions, the potential magnitude of REC/LEC double claiming is less than 5% of projected international aviation CO_2 emissions in 2050. In addition, a number of approaches to mitigate the double counting risk are presented, including:

- Correcting national inventories to account for claimed LEC/REC credits (which would completely eliminate the risk of double claiming but may be difficult to implement);
- Limiting net LCA values to a minimum of 0 gCO_2e/MJ (which is shown to significantly reduce the magnitude of the potential for double claiming); and
- Defining GHG reporting requirements for SCS, to enable national authorities to check for inconsistencies.

Milestone(s)
The work described above represents the achievement of MS 1, 2 and 3, as defined in the AY 2017/2018 Grant Proposal. Progress on core LCA default value calculations, and was presented to AFTF at meetings in October 2017, April 2018, and September 2018 and documented in numerous CAEP working and information papers. In addition, significant effort was expended in development of a methodology to account for LEC/REC associated with MSW-derived AJF. This was presented to the AFTF at meetings in April 2018 and September 2018 and documented in numerous CAEP working and information papers.

Major Accomplishments
A major accomplishment was the calculation of default CLCA values for eight additional pathways under CORSIA, and the agreement of AFTF to the proposed values. This progress will enable the inclusion and use of these fuels as soon as CORSIA goes into effect. In addition, a scientifically rigorous methodology was defined for accounting for LEC/REC associated with MSW-derived AJF.

Publications
Peer reviewed publications

Suresh, P, R Malina, MD Staples, S Lizin, H Olcay, D Blazy, MN Pearlson, SRH Barrett, 2018. Life cycle greenhouse gas emissions and costs of production of diesel and jet fuel from municipal solid waste. *Environmental Science and Technology,* DOI: 10.1021/acs.est.7b04277

Staples, MD, R Malina, P Suresh, JI Hileman, SRH Barrett, 2018. Aviation CO_2 emissions reductions from the use of alternative jet fuels. *Energy Policy,* 114, p. 342-354, DOI: 10.1016/j.enpol.2017.12.007

Project 01 funding is acknowledged in both of these publications.

Written reports

CAEP/11-AFTF/5-IP/03, Progress on calculation of default core life cycle analysis (LCA) values, presented at AFTF/5, October 2017, Brasilia, Brazil

CAEP/11-AFTF/5-WP/03, Progress on the core LCA task group, presented at AFTF/5, October 2017, Brasilia, Brazil

CAEP/11-AFTF/6-IP/06, Progress on calculation of default core LCA values, presented at AFTF/6, April 2018, Montreal, Canada.

CAEP/11-AFTF/6-WP/04, Summary of the work of CLCA-TG since AFTF05, presented at AFTF/6, April 2018, Montreal, Canada.

CAEP/11-AFTF/6-IP/08, Assessing LEC and REC for MSW-derived fuels within CORSIA, presented at AFTF/6, April 2018, Montreal, Canada.

CAEP/11-AFTF/7-IP/11, Progress on calculation of default core LCA values, presented at AFTF/7, September 2018, Montreal, Canada.

CAEP/11-AFTF/7-IP/04, Report on the progress of the MSW Crediting Small Group, presented at AFTF/7, September 2018, Montreal, Canada.

CAEP/11-AFTF/7-WP/06, Core LCA progress, September 2018, Montreal, Canada.

Outreach Efforts
Progress on these tasks were communicated during weekly briefing calls with the FAA and other U.S. delegation members to AFTF, numerous AFTF teleconferences between in-person meetings, as well as at in-person meetings of AFTF in October 2017, April 2018 and September 2018. In addition, MIT presented its work under Project 01 to ASCENT at the biannual meeting in April 2018, in Cambridge, MA.

Awards
None

Student Involvement

During the reporting period of AY 2017/2018, the MIT graduate students involved in this task were Paula do Vale Pereira, Juju Wang, and Uyiosa Oriakhi. Paula do Vale Pereira and Uyiosa Oriakhi were funded partially, and Juju Wang was fully funded, under ASCENT Project 01.

Plans for Next Period

In the coming year, the MIT ASCENT Project 01 team will continue its work in AFTF. Default core LCA values will be calculated and proposed for additional pathways. In addition, Prof. Robert Malina from Hasselt University will continue to lead the core LCA Task Group, and Dr. Mark Staples will continue to lead a small group responsible for dealing with emissions credits under CORSIA. The work of the core LCA Task Group during CAEP/11 will be summarized in a series of working paper and technical reports presented to CAEP in February 2019. MIT will take a lead role in drafting a number of these papers.

References

Argonne National Laboratory. (2015) Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) Model. [Online]. http://greet.es.anl.gov/

Bonomi, A., O. Cavalett, M.P. Cunha, and M.A.P. Lima. "Virtual biorefinery – an optimization strategy for renewable carbon valorization." 1st Ed. Basel: Springer International Publishing, 2016.

Chagas, M.F., R.O. Bordonal, O. Cavalett, J.L.N. Carvalho, A. Bonomi Jr., and N. La Scala. "Environmental and economic impacts of different sugarcane production systems in the ethanol biorefinery." Biofuels, Bioproducts and Biorefining, 10(1), 2016: 89-106.

Klein, B.C., M.F. Chagas, T.L. Junqueira, M.C.A.F. Rezende, T.d.F. Cardoso, O. Cavalett, and A. Bonomi. "Techno-economic and environmental assessment of renewable jet fuel production in integrated Brazilian sugarcane biorefineries." Applied Energy, 209, 2018: 290-305.

Ludwig-Bolkow Systemtechnik GMBH. (2006) E3 Database. [Online]. http://www.e3database.com/

Staples, M.D. et al. (2014). Lifecycle greenhouse gas footprint and minimum selling price of renewable diesel and jet fuel from fermentation and advanced fermentation production technologies. Energy and Environmental Science, 7, 1545-1554.

Task 2- Support of ILUC Calculations and Assessment of Sustainability Certification Schemes for Potential Inclusion Under CORSIA

Massachusetts Institute of Technology

See combined Tasks 2 & 6 below.

Task 3- Stochastic Techno-Economic Assessment (TEA) to Evaluate Alternative Jet Fuel Policies in the Context of CORSIA

Massachusetts Institute of Technology & Hasselt University

Objective(s)

For AY 2017/2018 Task 3, the objective of the funded work was to quantify the impact of different policy options on the economic viability of alternative jet fuel (AJF) production. This analysis was used to inform the work of the Policy Guidance Task Group of AFTF, by providing quantitative evidence of the effectiveness of policies that CAEP Member States may be considering to support the deployment of AJF technologies. The analysis leverages techno-economic work and models that MIT has developed previously, with the assistance of FAA funding.

Research Approach

Introduction

In previous years, MIT has carried out TEA studies for a wide set of feedstock-to-fuel pathways to convert biomass or industrial and household wastes into alternative aviation fuel. The resulting literature (eg., Bann et al., 2017; Yao et al., 2017; Suresh et al. 2018; Pearlson et al., 2013, Seber et al., 2014; Bond et al., 2014; Staples et al., 2014) shows that alternative aviation fuels will remain more expensive to produce than conventional jet fuel in the short- to medium-term. However, a number of policy measures exist that could potentially improve the economic viability of these technologies. Examples of such measures include loan guarantees, public offtake agreements, alternative fuel production or use mandates, production or consumption subsidies, tax breaks, carbon taxation or carbon offsetting mandates. In the U.S., for example, alternative aviation fuel support is provided, inter alia, through the Farm-to-Fly Program and its associated loan guarantees and support for alternative aviation fuel R&D and pilot plant development, the Renewable Fuels Standard (RFS) and by offtake agreements of the U.S. military.

To date, the monetary impact of only some of these options have been studied for a limited set of feedstock-to-fuel production pathways (Bann et al., 2017; Bittner et al., 2015). The available evidence points to heterogeneity in the cost-effectiveness of these policy measures. MIT (in collaboration with Purdue University and Hasselt University) has carried out an analysis of a wide set of policy options for a number of AJF production technologies.

This work was carried out in the context of the AFTF Policy Task Group, and made use of the harmonized stochastic TEA model developed at MIT (Bann et al., 2017). The model was augmented to account for several policy measures, and quantifies the changes in net present value (i.e. financial performance of a jet fuel production facility) and jet fuel minimum selling prices resulting from these policies.

Methods

The case studies considered for the stochastic TEA analysis are summarized in Table 11.

Table 11. Case studies selected for stochastic TEA policy assessment

Process	Feedstock	Region	Company example
Micro - Fischer-Tropsch (FT)	Forest residues	North America	Velocys
Synthesized iso-parrafins (SIP)	Sugarcane	South America	Total-Amyris
Hydroprocessed esters and fatty acids (HEFA)	Waste tallow and yellow grease	North America/ Europe	Altair/Neste
Hydroprocessed esters and fatty acids (HEFA)	Palm oil/palm fatty acid distillates (PFAD)	Asia & Pacific	Pertamina
FT	Municipal solid waste	North America	Fulcrum
Alcohol to jet (ATJ) via. iBuOH	Corn	US	Gevo

To carry out the TEA of the different AJF pathway case studies outlined above, a discounted cash flow rate of return (DCFROR) model was used. The DCFROR model quantifies the economic viability of an n^{th} plant, commercial-scale fuel production facility in terms of two metrics:

- Net Present Value (NPV), which is the value of all future cash flows, discounted to nominal dollars in the base year; and

- Minimum Selling Price (MSP), which is the lowest price at which the fuel product must be sold to have a project NPV of zero at the stipulated rate of return. By comparing the calculated MSP to conventional fuel prices, the cost premium (or discount) of producing the AJF fuel can be calculated.

This analysis builds off the DCFROR model first presented in Pearlson et al. (2013) and applied to middle distillate fuel production from soybean oil using the HEFA process. This model was subsequently extended to handle additional feedstock-to-fuel AJF pathways, and to quantify uncertainty in the results as a function of uncertainty and stochasticity in the input parameters, as described in Suresh et al. (2018) and Bann et al. (2017).

Each of the pathways modelled relies on a number of updated harmonized financial assumptions. Each AJF production plant is assumed to have a 20-year lifetime, with 40% equity financing. The remainder of the financing is assumed to be from a 10-year loan with 8% interest. The plants are assumed to operate for 350 days per year, with a deterministic nameplate capacity of approximately 111 million liters/year (2000 bbl/day) of total fuel product. Actual pathway capacity used in each iteration of the model varies somewhat with stochastic changes in fuel yield. The return on equity is 15%. The income tax rate was assumed to be 16.1%. Many of the input parameters are drawn from a probability distribution or stochastic process, in order to quantify uncertainty in their values and the calculated results. These include facility capital costs, fixed operating costs, feedstock costs, utility prices (electricity and natural gas), fuel product prices, and non-fuel product prices. Parameter values are drawn from these distributions and run through the DCFROR model 10000 times, in order to generate a distribution of MSP and NPV results. Where possible, regionally specific data was used to reflect the location of the selected case studies. The parameter values and distributions, as well as the mass and energy balance data used for each of the pathways, is documented in detail in CAEP/11-AFTF/07-IP/14.

A number of policy types were implemented in the stochastic TEA model. These are summarized in Table 12. For the GHG emissions reduction-based incentive, each pathway's reduction in emissions is based on LCA values already agreed to by AFTF, or our best estimate of what the agreed default LCA values are likely to be.

Table 12. Policy types to be considered in the stochastic TEA policy assessment

Policy type	Implementation in stochastic TEA model
Input subsidy	Reduce feedstock costs seen by fuel producer by subsidy amount
Capital grant	Reduce initial capital cost by grant amount
Output based incentives	Increase prices received by fuel producer for products by incentive amount
GHG emission reduction-defined incentive	Increase prices received by fuel producer for products, as a function of GHG reduction from petroleum fuels

Results

Figure 1 shows the MSP of the six case studies modelled, and serves as a reference point when no policies have been applied. The red line indicates the median value of calculated MSP, and the bold blue line represents current market prices for petroleum-derived jet fuel.

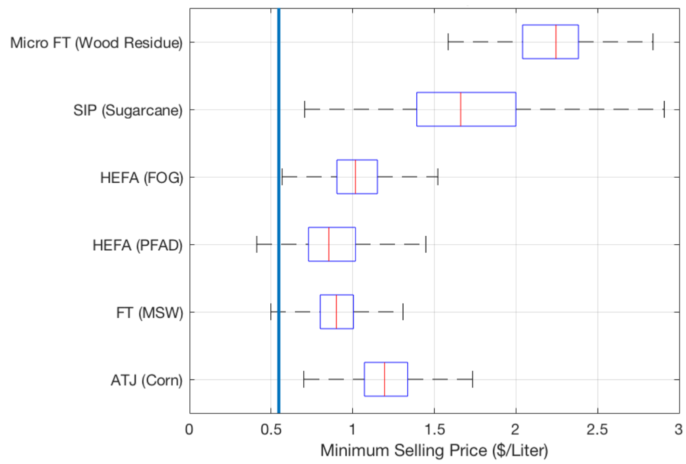

Figure 1. MSP of the six modelled case studies

Next, each of the policies described above was implemented with the same total cost to the government. In order to do this for the HEFA pathways, for example, the first policy modelled was the output subsidy at three levels: 0.10, 0.25, 0.75 USD per liter output subsidy. The average total cost to the government was calculated, and this was used to determine a comparable size for the capital grant, input subsidy, and GHG reduction-based incentive policies. Example results for the HEFA FOG pathway are shown in Table 13. The results for the other pathways are fully documented in CAEP/11-AFTF/07-IP/14.

Table 13. Policies cases for each of the 4 policy types and the resulting total policy costs and impact on fuel MSP for the HEFA FOG pathway. Mean values are provided with variance in brackets.

HEFA (FOG)			
Policy type	**Output Subsidy**		
Policy	0.10 $/liter output subsidy	0.25 $/liter output subsidy	0.75 $/liter output subsidy
Total policy cost (mil. USD) [Standard Deviation]	77 [3]	192 [8]	576 [23]
MSP ($/liter) [Standard Deviation]	0.97 [0.19]	0.82 [0.19]	0.32 [0.19]
Policy type	**Input Subsidy**		
Policy	16% subsidy on feedstock costs	40% subsidy on feedstock costs	119% subsidy on feedstock costs
Total policy cost (mil. USD) [Standard Deviation]	77 [19]	192 [50]	571 [146]
MSP ($/liter) [Standard Deviation]	0.98 [0.17]	0.81 [0.12]	0.25 [0.05]
Policy type	**Capital Grant**		
Policy	74 mil. USD capital grant	79 mil. USD capital grant*	79 mil. USD capital grant*
Total policy cost (mil. USD) [Standard Deviation]	74 [4]	79 [9]	79 [9]
MSP ($/liter) [Standard Deviation]	0.88 [0.19]	0.87 [0.19]	0.87 [0.19]
Policy type	**GHG Emissions Reduction Policy**		
Policy	CO_2 reduction credit of 48 USD/tonne	CO_2 reduction credit of 114 USD/tonne	CO_2 reduction credit of 343 USD/tonne
Total policy cost (mil. USD) [Standard Deviation]	77 [3]	192 [8]	576 [23]
MSP ($/liter) [Standard Deviation]	0.97 [0.19]	0.82 [0.19]	0.32 [0.19]

*The size of the capital grant in these cases is limited by total estimated fixed capital investment (FCI): we have not considered capital grants that exceed total FCI.

These results show that, at equivalent total policy costs, different policies have different impacts on the mean and variance of MSP. In particular, the capital grant is most effective at reducing mean MSP because the benefit of the policy to the fuel producer is not taxed. Note that this result is sensitive to the way loans are treated and paid off in the DCFROR model: in these results, the debt-to-equity ratio is assumed to remain constant, whereas in reality a capital grant may instead be used preferentially to reduce debt or equity.

In contrast, feedstock input subsidies are shown to be more effective at reducing risk (as indicated by the impact on variance in MSP) than the other policies considered here, even at the same total policy cost. Furthermore, as the size of the feedstock subsidy increases, variance in MSP decreases. This is because variability in feedstock costs is a significant contributor to uncertainty in MSP, and as the policy is implemented as a percentage of total feedstock cost, the risk of variability in feedstock costs is offloaded onto the policy. These results indicate that policy makers may wish to select different policy mechanisms depending on their objectives.

The results shown in Table 13 indicate that a large enough feedstock subsidy, output subsidy or GHG reduction-based incentive could reduce the MSP of jet fuel to be competitive with today's jet fuel market price of 0.55 USD per liter. Therefore, the magnitude of each policy type required to have a project NPV of zero was also calculated. For example, the results for the breakeven feedstock subsidy for five of the fuel production pathways are shown in Figure 2. The results indicate that

HEFA PFAD and FOG pathways would require a median feedstock subsidy of 13% and 47% percent, respectively, to have a project NPV of 0. The corn grain ATJ and sugarcane SIP pathways would require feedstock subsidies of 80% and 93%, respectively, in the median cases. The results for the forestry residue micro FT pathway are around 430% in the median case, meaning that the micro FT pathway would have to receive a subsidy of approximately 4 times the costs of feedstock in order to be profitable. Note that the black lines in the figure indicate 0-100%, and that the MSW FT case is not shown in Figure 2 because the assumption is that there is no cost associated with the feedstock.

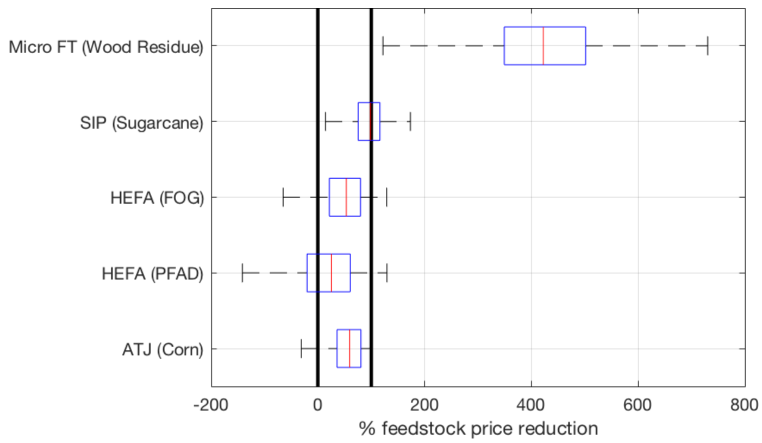

Figure 2. Breakeven feedstock subsidy for four fuel production pathways.

A similar analysis was carried out for the other policy types. In addition, the analysis included an assessment of the impact of real-world policies on the economic viability of the six feedstock-to-fuel pathways. These illustrative policies investigated included: a feedstock subsidy of 50 USD/tonne for PFAD, suggested by the technical experts from Indonesia (~approx. 27% of feedstock cost); a capital grant of 5 mil. USD (comparable to capital grants awarded under the US Department of Energy and Bioenergy Technologies Office); CO_2 emissions credits of 8 USD/tonne$_{CO2}$ in 2020, ramping up to 20 USD/tonne$_{CO2}$ by 2035 (the carbon pricing assumptions used by GMTF in a cost-benefit assessment of CORSIA); and an output subsidy of 0.25 USD/l (similar to historical highs seen for RIN prices under the US Renewable Fuels Standard (US EPA 2015)).

Milestone(s)

The work described for this task represents the achievement of MS 4 as defined in the AY 2017/2018 Grant Proposal. Progress on stochastic TEA policy analysis was presented to AFTF at meetings in April 2018 and September 2018 and documented in numerous CAEP working and information papers.

Major Accomplishments

The major accomplishments were the calculation of the stochastic TEA results for 6 feedstock-to-fuel pathways, considering 4 different policy types of various magnitudes. These data were presented to AFTF and documented in CAEP information and working papers and will ultimately be passed on to CAEP in order to inform policies being considered by Member States.

Publications

Peer reviewed publications

None

Written reports

CAEP/11-AFTF/6-IP/05, Stochastic techno-economic analysis for quantitative policy assessment, presented at AFTF/6, April 2018, Montreal, Canada

CAEP/11-AFTF/7-IP/14, Stochastic techno-economic analysis for quantitative policy assessment, presented at AFTF/7, September 2018, Montreal, Canada

Outreach Efforts

Stochastic techno-economic analysis for quantitative policy assessment. Presented by Juju Wang on the at ASCENT 1 bi-weekly teleconference on March 5, 2018.

Awards

None

Student Involvement

Juju Wang, Master's student at MIT's Department of Aeronautics and Astronautics, carried out the majority of the analysis. This work will make up the majority of her master's thesis, and she is expected to graduate in June 2019.

Plans for Next Period

In the coming year, the MIT ASCENT Project 01 team will continue its work in AFTF. The quantitative policy assessment work carried out to date will be augmented, and then documented in a working paper to be presented to CAEP in February 2019. MIT will draft this working paper.

In addition, this work will start to be prepared for submission to a peer-reviewed journal. Much of the analysis carried out for this task will be written up in a Master's thesis to be submitted by Juju Wang for anticipated graduation in June 2019.

References

Bann, S.J., Malina, R., Staples, M.D., Suresh, P., Pearlson, M., Tyner, W.E., Hileman, J.I., Barrett, S.R.H., *The costs of production of alternative jet fuel: A harmonized stochastic assessment.* Bioresource Technology, Volume 227, 2017

Bittner, A, Tyner, WE., Zhao, X, Field to flight: A techno-economic analysis of the corn stover to aviation biofuels supply chain. Biofuels, Bioprod. Bioref., 9: 201–210 (2015).

Bond, J; Upadhye, A; Olcay, H; Tompsett, G; Jae, J; Xing, R; Alonso, D; Wang, D; Zhang, T; Kumar, R; Foster, A; Sen, S; Maravelias, C; Malina, R; Barrett, S; Lobo, R; Wyman, C; Dumesic, J; Huber, G. Production of renewable jet fuel range alkanes and commodity chemicals from integrated catalytic processing of biomass, In: Energy and Environmental Science, Vol. 7 (2014).

Pearlson, M., Wollersheim, C., Hileman, J., 2013. A techno-economic review of hydroprocessed renewable esters and fatty acids for jet fuel production. Biofuels, Bioprod. Biorefin. 7, 89–96. http://dx.doi.org/10.1002/bbb.1378.

Seber, G; Malina, R; Pearlson, M; Olcay, H; Hileman, J; Barrett, S. Environmental and economic assessment of producing hydroprocessed jet and diesel fuel from waste oils and tallow, Biomass and Bioenergy Vol. 67 (2014).

Staples, M. D., Malina, R., Olcay, H., Pearlson, M. N., Hileman, J. I., Boies, A., & Barrett, S. R. H. (2014). Lifecycle greenhouse gas footprint and minimum selling price of renewable diesel and jet fuel from fermentation and advanced fermentation production technologies. Energy Environ. Sci., 7(5), 1545–1554. https://doi.org/10.1039/C3EE43655A

Suresh, P, R Malina, MD Staples, S Lizin, H Olcay, D Blazy, MN Pearlson, SRH Barrett, 2018. Life cycle greenhouse gas emissions and costs of production of diesel and jet fuel from municipal solid waste. *Environmental Science and Technology,* DOI: 10.1021/acs.est.7b04277

Yao, G; Staples, M. / Malina, R; Tyner, WE: Stochastic Techno-Economic Analysis of Alcohol- to-Jet Fuel Production, in: Biotechnology for Biofuels, Vol. 10, 18 (2017).

Task 4- Collaborate with ASCENT 21 to Incorporate Non-CO_2 Lifecycle Emissions into APMT-Impacts Climate

Massachusetts Institute of Technology

Objective(s)

The objective of this task was to collaborate with Project A021 to incorporate non-CO_2 lifecycle GHG emissions into APMT-IC and to evaluate the impact that the choice of climate metric has on results and conclusions from APMT-IC.

Research Approach

Introduction

The MIT ASCENT Project 01 team collaborated with the Project A021 team to properly represent AJF in the APMT-IC module. AMPT-IC was developed by MIT under the Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER) to quantify the environmental impacts of policies influencing aircraft operations and the resulting changes in health and welfare outcomes for climate, air quality and noise. Previously, APMT-IC represented the differences between petroleum-derived jet fuels and AJF in terms of lifecycle CO_2-equivalent emissions, where the CO_2e value of CH_4 and N_2O emissions are calculated on the basis of 100-year global warming potential (GWP) equivalents. While this approach is useful as a first-order approximation to quantify the lifecycle climate impacts of different jet fuels, the use of 100-year GWP to capture non-CO_2 emissions misrepresents the climate impacts. For instance, the atmospheric background concentrations, radiative forcing, and atmospheric lifetime of CH_4 and N_2O are fundamentally different than those of CO_2. Using an equivalency metric that depends on an arbitrarily defined time horizon, such as the GWP-100, masks these physical differences, and that could distort the results at each step of the analysis. Therefore, in order to better reflect non-CO_2 lifecycle emissions in APMT-IC, it was proposed under ASCENT Project 21 to model lifecycle CH_4 and N_2O emissions to quantify their impacts on radiative forcing.

Methods

The MIT Project 01 team contributed to this improvement of APMT-IC by providing lifecycle emissions inventories for petroleum and AJF, disaggregated by emissions species, to the Project A021 team. This data was used to verify and validate the modifications made to APMT-IC. The results have been used to evaluate the impact that the choice of climate metric has on results and conclusions from APMT-IC, and to enhance the ability to assess policies influencing the use of AJF.

Results

The results obtained from the newly implemented model were verified through comparisons the Model for Greenhouse Gas Induced Climate Change (MAGICC6) (Meinshausen et al., 2011) and the global warming potential was compared to results published in the IPCC Fifth Assessment Report (Myhre et al. 2013) and Cherubini et al. (2013). In both cases the implemented model was found to align with results in the literature.

These additional capabilities enable APMT-IC to not only evaluate aviation life-cycle emissions scenarios, but also to evaluate non-aviation emissions scenarios for ground emissions of CH_4, N_2O and CO_2. In addition, the current method is capable of capturing the associated climate impacts on their characteristic time scales. These new capabilities have already been applied in a paper accepted for publication in *GCB Bioenergy*. The paper illustrates the importance of capturing the emissions time scales, especially with regard to land use change emissions.

Milestone(s)

The work on this task represents the achievement of MS 6 as defined in the AY 2017/2018 Grant Proposal. The improvements made to APMT-IC, including the differentiation of lifecycle CO_2, CH_4 and N_2O emissions, was presented at the bi-annual ASCENT meeting in April 2018, in Cambridge, MA.

Major Accomplishments

The major accomplishment during this period of performance was the incorporation of lifecycle CH_4 and N_2O into APMT-IC, so that the climate impacts of technology pathways emitting these species can be better represented in the model. In addition, the enhanced model was used in a project to evaluate the time-dependent climate impacts of different bio-energy systems, relative to fossil fuels. This study was accepted for peer reviewed publication in *GCB Bioenergy*.

Publications

de Jong, S, MD Staples, C Grobler, V Daioglou, R Malina, SRH Barrett, R Hoefnagels, A Faaij, M Junginger, 2018. Using dynamic relative climate impact curves to quantify the climate impact of bioenergy production systems over time. *GCB Bioenergy,* DOI: 10.1111/gcbb.12573

Project 01 funding is acknowledged in this publication.

Outreach Efforts

This work was presented at the ASCENT bi-annual meeting in April 2018, in Cambridge, MA.

Awards

None

Student Involvement

These modifications to APMT-IC were carried out by Carla Grobler, a graduate student at MIT, who is primarily funded by Project A021. Lifecycle emissions inventories for petroleum-derived jet fuel and AJF were provided by Tim Galligan and Juju Wang, MIT graduate students funded under ASCENT Project 01.

Plans for Next Period

None

References

Cherubini, F., Bright, R.M. and Strømman, A.H., 2013. Global climate impacts of forest bioenergy: what, when and how to measure? *Environmental Research Letters* 8(1), p.014049.

Meinshausen, M., Raper, S. C. B. and Wigley, T. M. L. (2011). Emulating coupled atmosphere-ocean and carbon cycle models with a simpler model, MAGICC6 - Part 1: Model description and calibration. *Atmospheric Chemistry and Physics* 11(4), pp. 1417–1456. doi: 10.5194/acp-11-1417-2011.

Myhre, G. et al. (2013). Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I', in Stocker, T. F. et al. (eds) *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Task 5- Collaborate with Washington State University (WSU) to Facilitate Development of an Aspen Model of the Hydroprocessed Esters and Fatty Acids (HEFA) Fuel Production Process

Massachusetts Institute of Technology

Objective(s)

The objective of this task was to collaborate with Washington State University (WSU) ASCENT Project 01 team to facilitate development of an Aspen model of the HEFA fuel production process.

Research Approach

Under this task, the MIT ASCENT Project 01 team agreed to facilitate development of an Aspen model of the HEFA fuel production process by the ASCENT Project 01 research team at WSU. The HEFA model developed by WSU leverages the knowledge gained during development of the model described in Pearlson et al. (2013). The purpose of this task was to build up a modeling tool suited for use in WSU's lipid-focused advanced supply chain deployment support project, which is Task 3.1 of the ASCENT Project 01 Regional Project Planning numbering system.

During the reporting period, the MIT Project 01 team had a number of conversations with the WSU Project 01 team led by Manuel Garcia-Perez. The state of the Aspen HEFA model described in Pearlson et al. (2013) was discussed, along with the challenges encountered and lessons learned. Some clarifying questions regarding the data reported in the paper were also clarified. These interactions aided WSU's development of a higher fidelity Aspen model of the HEFA process.

Milestone(s)
This collaboration was discussed during the bi-weekly ASCENT Project 01 teleconference on November 13, 2017. This represents completion of MS 5 as defined in the AY 2017/2018 Grant Proposal.

Major Accomplishments
This major accomplishment of this reporting period was collaboration between MIT and WSU, to facilitate WSU's development of an Aspen HEFA model.

Publications
None

Outreach Efforts
None

Awards
None

Student Involvement
None

Plans for Next Period
None

References
Pearlson, M; Wollersheim, C; Hileman, J. A Techno-economic Review of Hydroprocessed Renewable Esters and Fatty Acids for Jet Fuel Production, Biofuels Bioprod. Biorefining 7, 89 (2013).

Tasks 2 & 6- Support of ILUC Calculations and Assessment of Sustainability Certification Schemes for Potential Inclusion Under CORSIA & Additional (including in-person) Support to FAA for Decision-Making in the Context of AFTF
Massachusetts Institute of Technology

Objective(s)
The objective of this task is to provide support to the FAA in the context of AFTF beyond the major LCA and policy analysis tasks outlined above. Specifically, this task will support the work of the induced land use change (ILUC) and sustainability task groups and provide in-person support for FAA decision-making at meetings of AFTF and CAEP.

Research Approach
ILUC Task Group

The ILUC Task Group is responsible for the calculation of ILUC emissions factors which are added to the core LCA values. Purdue University and the University of Toronto currently lead this task within AFTF. During the reporting period, the MIT ASCENT Project 01 team supported the work of the ILUC Task Group by:

- providing relevant pathway and technology-specific data (e.g. expected fuel yields, fuel product slates) and scenario assumptions (e.g. anticipated global fuel production volumes) for ILUC analysis such that the work is consistent with the work of the LCA Task Group;
- identify additional pathways for which ILUC values may be required (e.g. fuels derived from valuable by-product feedstocks, such as palm fatty-acid distillates or corn oil); and
- contributing to discussion on comparison of ILUC results from the GTAP and GLOBIOM models.

Sustainability Task Group
In order to qualify under CORSIA, AJFs have to satisfy sustainability criteria beyond the CO_2 reductions that are captured in the LCA and ILUC emissions analyses. During the reporting period, it was decided that these criteria would encompass only a limited set of environmental aspects. Therefore, the contribution of MIT ASCENT Project 01 team was smaller than anticipated because the scope of work was significantly reduced.

In-person Support
During the reporting period, the MIT ASCENT Project 01 team will provided significant in-person support for FAA decision-making for purposes of the AFTF. Prof. Robert Malina from Hasselt University served as the co-lead of the task group on core LCA emission values and the small group lead on feedstock classification and reporting requirements. Dr. Mark Staples from MIT led the modeling work of the AFTF Task Group for Core LCA and the small group on emissions credits. Team members took part in AFTF in-person meetings in October 2017, April 2018 and September 2018, as well as the ICAO Alternative Fuels Conference in Mexico in fall 2017, as requested by FAA. Team members also participated in numerous teleconferences, virtual meetings, and the preparation of CAEP information and working papers.

Milestone(s)
Participation in AFTF/05, AFTF/06, AFTF/07, and the ICAO Alternative Fuels Conference in fall 2017.

Major Accomplishments
None

Publications
Peer reviewed publications
None

Written reports
CAEP/11-AFTF/7-IP/12, Report on the progress of the feedstock classification small group, presented at AFTF/7, September 2018, Montreal, Canada

CAEP/11-AFTF/7-IP/13, Reporting requirements for actual GHG emissions LCA values, presented at AFTF/7, September 2018, Montreal, Canada

Outreach Efforts
None

Awards
None

Student Involvement
None

Plans for Next Period
In the coming year, the MIT ASCENT Project 01 team will continue its work in AFTF, the specific scope of which depends on decisions to be reached by CAEP in February 2019. The work carried out to-date will be documented in a number of working papers to be presented to CAEP at that meeting.