Project 001(D) Alternative Jet Fuel Supply Chain Analysis

Purdue University

Project Lead Investigator

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University Participants

Purdue University

- Wallace E. Tyner, James and Lois Ackerman Professor
- FAA Award Number: 13-C-AJFE-PU
- Period of Performance: July 14, 2014 – August 31, 2016
- Tasks:
  1. Evaluate the current state of techno-economic analysis (TEA) for the pathways and identify pathways and variables for stochastic analysis. This research will draw upon previous work from MIT and inputs from NREL and PNNL.
  2. Develop stochastic techno-economic models for relevant pathways and identify key stochastic variables to be modeled for assessing risk in conversion pathways.
  3. Work with the CAEP/AFTF life cycle assessment committee (WP3) on issues such as system boundaries, induced land use change, LCA methodology, and pathway GHG emissions assessment.

Project Funding Level

Amendment 3 - $250,000, Amendment 6 - $110,000, Amendment 10 - $230,000
Cost sharing is from United Airlines (currently unused), Boeing (currently unused), Honeywell (currently unused), National Biodiesel Foundation ($120,203 and $17,170), Indiana Corn Marketing Council ($29,994 and $37,322), Oliver Wyman ($500,000), and Monsanto ($54,000 for data used).

Investigation Team

Wallace E. Tyner, James and Lois Ackerman Professor, is the primary investigator for this project.

Farzad Taheripour is a research associate professor at Purdue University is involved in several aspects of the project, but especially life cycle analysis and land use change

Xin Zhao and Guolin Yao are PhD students at Purdue University and are involved in the stochastic technoeconomic analysis.

Project Overview

For the stochastic techno-economic analysis, Purdue will develop techno-economic spreadsheets for each conversion pathway. These will be done using the Pallisade Systems Excel add-in, called @Risk. Normally, key parameters will be identified for the risk analysis. For example, in a recent study of the corn stover to jet pathway, the key uncertain variables were feedstock cost, conversion efficiency (yield), hydrogen cost, capital cost, and future aviation biofuel prices. For the technical inputs, one commonly uses either a Pert or a Triangular distribution, both of which have the minimum, maximum, and mode as input parameters. Sometimes the Delphi technique is used to query experts for distribution parameters. Other sources include data from experiments conducted in the field or from the literature.

The output of the risk analysis is the distribution of net present value (NPV), internal rate of return (IRR), the probability the investment will lose money, and a distribution of breakeven prices. All these output distributions reflect the inherent uncertainty in project inputs. Being able to provide a distribution of financial outputs is immensely valuable to private sector investors and other players. The analysis outputs can also be used to help target future research to areas where the research outcome could be expected to have a high payoff.

For the life cycle and land use change analysis, Tyner and Taheripour will draw on their extensive experience in the area to provide inputs to the CAEP/AFTF. The AFTF has two major areas plus synthesis. Tyner will work on both the life cycle analysis and fuels production topics, but will concentrate on life cycle analysis. Within the life cycle analysis topic, Tyner will focus on system boundaries and approaches for estimating induced land use change. Tyner will also provide inputs on allocation method, LCA methodology, and GHG assessment for alternative pathways. Tyner and Taheripour are doing simulations using the Global Trade Analysis Project (GTAP) model to produce land use change and emissions estimates for alternative aviation biofuel pathways.

Task 1

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Objective(s)

Evaluate the current state of techno-economic analysis (TEA) for the pathways and identify pathways and variables for stochastic analysis. This research will draw upon previous work from MIT and inputs from NREL and PNNL.

Research Approach

We have completed the literature review for stochastic technoeconomic analysis and have included appropriate literature in submitted and published papers.

Milestone(s)

The literature review is complete

Major Accomplishments

We have a library of all the relevant papers in the area that is available to all students working in the area. That will facilitate the work of future students.

Publications

See below.

Outreach Efforts

See task 2 below.

Awards
See description under task 2.

Student Involvement
Xin Zhao – PhD student, Purdue University
Guolin Yao – PhD student, Purdue University

Plans for Next Period
We will continually update the literature review. See task 2 for other plans for stochastic technoeconomic analysis.

Task 2
Purdue University

Objective(s)
Develop stochastic techno-economic models for relevant pathways and identify key stochastic variables to be modeled for assessing risk in conversion pathways.

Research Approach
As indicated above, our approach has been to identify variables in the technoeconomic analysis which are uncertain and for which the actual value is significant in the economics of the process. Then we obtain information on the appropriate distributions to use for each uncertain variable. Once the spreadsheet model is developed with all the technical and economic relationships included, we simulate the model to obtain distributions for NPV, IRR, and breakeven price. These distributions add a new richness to the comparison of alternative pathways.

Milestone(s)
Our milestones basically are development, submission, and publication of journal papers and extension or public awareness papers on our work.

Major Accomplishments
Over the past year, we have published one paper, have a second accepted for publication, and a third submitted for publication – all on stochastic technoeconomic analysis.

Publications
- Bittner, Amanda, Xin Zhao, and Wallace E. Tyner. Field to Flight: A Techno-Economic Analysis of Corn Stover to Aviation Biofuels Supply Chain." *Biofuels, Bioproducts & Biorefining* 9, 201-210, 2015.
- Zhao, Xin, Tristin R. Brown, and Wallace E. Tyner. "Stochastic techno-economic evaluation of cellulosic biofuel pathways." *Bioresource Technology*, forthcoming 2015.

Outreach Efforts
Tyner did a presentation at the March and October ASCENT project meetings. In addition we published the following CAAFI paper and an extension paper:

- Tyner, Wallace E., and Kirsten van Fossen. "Policy Research Needs Relevant to Alternative Jet Fuels." CAAFI Research and development Team White Paper Series: Policy Impact (2014), http://www.caafi.org/information/pdf/8_CAAFI_Policy_Paper_Final_December_2014.pdf
- Bittner, Amanda, Wallace E. Tyner, and Xin Zhao. *Field to Flight: A Techno-Economic Analysis of the Corn Stover to Aviation Biofuels Supply Chain*. Purdue Extension RE-8-W, 2014.

Awards
Tyner received the Morrill award from Purdue University in recognition of outstanding career accomplishments that have had impact on society.

Tyner was named an Honorary Life Member by the International Association of Agricultural Economists, that association's highest award, equivalent to fellow in other societies.

Student Involvement
Xin Zhao – PhD student, Purdue University
Guolin Yao – PhD student, Purdue University

Plans for Next Period
We will be developing a new stochastic technoeconomic analysis for a proprietary process that shows considerable promise.

Task 3
Purdue University

Objective(s)
Work with the CAEP/AFTF life cycle assessment committee (WP3) on issues such as system boundaries, induced land use change, LCA methodology, and pathway GHG emissions assessment.

Research Approach
There are many varied assignments and pieces under this task. For life cycle analysis we work with other team members, using standard approaches for consequential LCA. For system boundaries we have investigated the consequences of different approaches to defining system boundaries. For estimating induced land use change we use the GTAP model and are in the process of modifying and updating databases to be able to provide state of the art estimates.

Milestone(s)
Tyner participated in the AFTF meeting in Brazilia in May 2015 and will participate in the Montreal meeting in October 2015. He has been involved in many of the tasks and document preparation for the meetings. In Brazilia, he presented on induced land use change and the California Air Resources Board approach.

Major Accomplishments
Most of the accomplishments under this task are in the form of work progress of ICAO/CAEP/AFTF. The group is making significant progress under the leadership of James Hileman and Maria del Mar Rica Jimenez.

Publications
- Mueller, Steffen, Stefan Unnasch, Wallace E. Tyner, Jennifer Pont, and Jane M-F Johnson. "Handling of co-products in life cycle analysis in an evolving co-product market: A case study with corn stover removal." *Advances in Applied Agricultural Science* 3(5) 2015, pp. 8-21.

Outreach Efforts
As indicated above, Tyner gave a presentation at the AFTF meeting in Brazilia. He will give a presentation at the October 2015 ASCENT meeting on induced land use change.

Awards
See task 2.

Student Involvement
No graduate students are involved in this task. Tyner works with Farzad Taheripour, Research Associate Professor.

Plans for Next Period
We plan on developing a new method for handling changes in GTAP on the intensive margin. The intensive margin refers to things such as double cropping, irrigation, etc. GTAP has been modified and improved considerably in dealing with changes on the extensive margin, but now needs work on the intensive margin.