Project #ASCENT COE-2014-01

Techno-Economic Evaluation of Alternative Jet Fuel Conversion Processes: Cost Reduction Opportunities in Integrated Biorefinery Concepts

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Motivation and Objectives

There are numerous processes, the product of both academic and commercial research, which offer possibilities for the conversion of renewable biomass resources to sustainable alternative jet fuels. Each of these strategies encounter certain barriers toward their implementation on an industrial level. In this project, we aim to compare strategies on an even level to provide data for the evaluation of potential full scale implementation as well as to identify opportunities to enable whole biorefineries in the near-term. Leveraging existing infrastructure from dominant industries in a region by integrating alternative jet fuel production reduces the risk of biorefinery investment. Value-added co-products can also improve biorefinery economics by provide additional revenue streams in non-fuel markets. It is clear that innovative strategies for complete biorefineries are necessary to overcome the economic and technical barriers facing alternative jet fuel production.

Objectives:

•Evaluate technical and economic barriers to implementation of individual technologies

•Identify unique opportunities to improve the economics of complete biorefinery concepts

•Compare conversion alternatives for alternative jet fuel production in different regions as part of a supply chain

Methods and Materials

This investigation is based on four subtasks:

•Collect a "database" of the key design cases and evaluate the merits of individual technologies
•Identify opportunities for synergy between alternative jet fuel strategies and existing infrastructure, forming complete biorefinery concepts
•Examine intermediate streams and potential routes to generate value-added co-products
•Conduct techno-economic analyses of alternative jet fuel strategies to improve modeling of biorefinery and supply chain economics

Summary

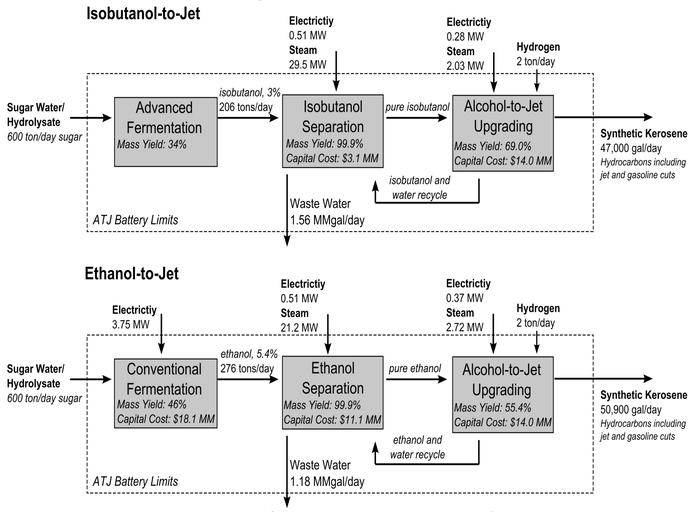
While several AJF conversion pathways have demonstrated the potential to produce advanced renewable jet fuel at commercial scale, certain technical and economic barriers prevent their adoption at full scale. Numerous variables should be compared between them to help identify unique and innovative opportunities to improve the economics of a complete biorefinery and its supply chain.

Comparisons for Individual Conversion Processes:

Conversion Process	Feedstock	Hydrogen Required	Hydrocarbon Output Range	Energy Yield	Jet Fuel Mass Yield	Co-products
Fisher-Tropsch + Aromatics	Forest Residues	No	*Jet, Diesel Naphtha*	40% - 53%	16% - 17%	Electricity
Pyrolysis	Forest Residues	Yes	*Jet, Diesel Gasoline*	55%	24%	Char
Virent Bioforming	Corn stover	Yes	*Jet, Diesel Naphtha*	26%	22%	Steam
Alcohol-to-Jet	Sugars	Yes	*Jet, Diesel*	24%	26%	Chemicals Polymer Precursors
Direct Sugars to Hydrocarbons	Sugars	Yes	*Jet, Diesel Naphtha*	50%	12%	Chemicals Polymer Precursors
Catalytic Hydrothermolysis	Renewable Oils	Yes	*Jet, Diesel Gasoline Liquid Propane Gas*	70%	75%	Chemicals Polymer Precursors

The conversion pathways under investigation were chosen based on alternative fuels recently approved or under investigation by ASTM for commercial use.

Individual Technology Case: Mass Balances, Energy Requirements, and Capital Costs for the Alcohols-to-Jet Process



The Alcohol-to-Jet (ATJ) Process is based around the catalytic upgrading of alcohols produced from renewable sources such as fermentation of corn sugars or hydrolyzed cellulose. Both conventional fermentation of ethanol and more advanced fermentation processes can be used. Advanced fermentation uses proprietary genetically modified organisms and technology to produce higher-order alcohols, potentially resulting in higher yield and lower costs.

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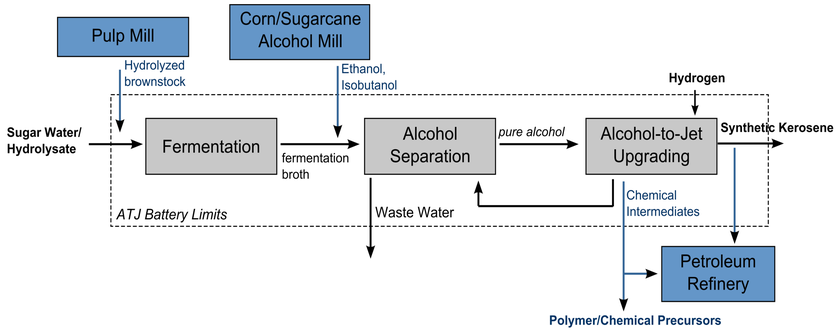
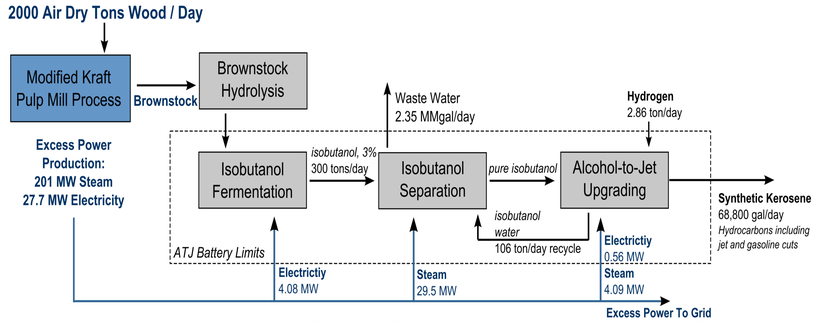
Results and Discussion

The process models developed for independent conversion processes will allow us to compare the production costs for multiple scenarios and integration options. Industries examined for integration potential were selected to represent dominant industries available to be leveraged in separate regions of the United States

Integration Opportunities Identified with the Alcohol-to-Jet Pathway:



Pulp Mill Integration Concept:



In this integration case, a modified kraft pulp mill is used to provide feedstock and power to the ATJ process. A typical mill processing 200 air dry tons of wood chips per day can generate approximately 68,000 gallons of jet fuel blendstock per day. The mill also becomes a net energy producer, capable of selling excess energy to the grid or using excess biomass and energy for the generation of other co-products.

Conclusions and Next Steps

1. Although these conversion processes are demonstrated to be capable of producing renewable jet fuel, none are economically viable as stand-alone facilities in the current economic environment
2. The key economic barriers hindering alternative jet fuel implementation are: high capital cost and risk, low product yield, and uncertainty of markets and supply chains
3. Integration with existing industry can help alleviate these concerns by reducing new process equipment, utilizing established supply chains, eliminating need for greenfield facilities, and minimizing outside battery-limits costs
4. Using other industries and opportunities such as co-product generation is critical to the implementation of AJF strategies, particularly in the short-term

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