ASCENT
AVIATION SUSTAINABILITY CENTER

Project #ASCENT COE-2014-01
Techno-Economic Evaluation for Alcohol-to-Jet Conversion Pathway and Integration with Pulp Mill Infrastructure

Scott Geleynse, Senthil Subramaniam, Manuel Garcia-Perez, Michael Wolcott*, Xiao Zhang*

WASHINGTON STATE UNIVERSITY

Introduction

With the recent addition of the Alcohol-to-Jet (ATJ) Conversion Pathway to ASTM D7566 Standard for Aviation Fuels Containing Synthesized Hydrocarbons, any source of fermented ethanol or isobutanol may be used to produce a jet fuel blendstock called ATJ-SPK. In this project, process engineering and simulation tools are applied to generate process and economic models for the ATJ conversion process. These models are useful for estimating the cost and impact of alternative jet fuels (AJF) and for evaluating the needs for research and commercialization efforts to further AJF adoption.

Kraft pulp mills have long been considered as an opportunity to facilitate fermentation-based conversion strategies through integration with certain pulping operations. Our Pulp-ATJ Biorefinery Models explore this possibility for the ATJ Pathway by evaluating changes in plant operation and economics when portions of the mill are retrofitted to produce aviation fuel through ATJ conversion.

Objectives

- Construct process and economic models to predict the performance, cost, and impact of the ATJ pathway for the production of alternative jet fuels
- Support other ASCENT projects through sharing and developing technical models and methodology
- Identify potential opportunities for reduction in cost and impact of ATJ-SPK production through integration of ATJ production with existing industrial infrastructure

Methods

Economic models are constructed using a cost-benefit model built using ASCENT standard methods and assumptions. Capital and operating costs for each process is adapted from reliable literature sources where possible; additional cost data are generated using process simulation and pre-estimation tools (Aspen Plus, SuperPro Designer). Co-product fuel (gasoline and diesel) prices are correlated to MSP of jet fuel, following historical trends.

Energy balance and boiler system operation data for the Pulp-ATJ Biorefinery are based on a variety of average pulp mill data available in literature.

References

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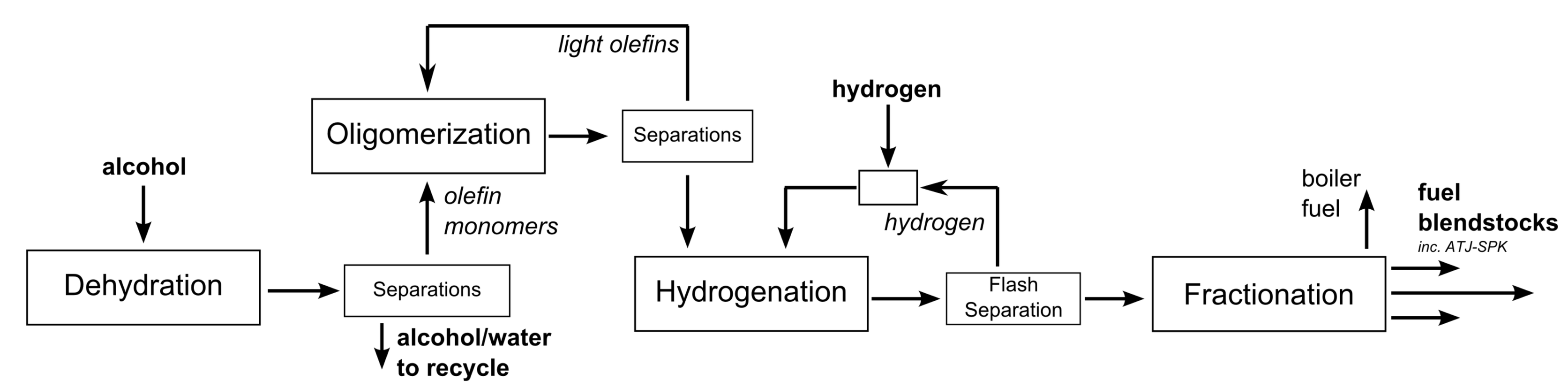
The Alcohol-to-Jet Pathway

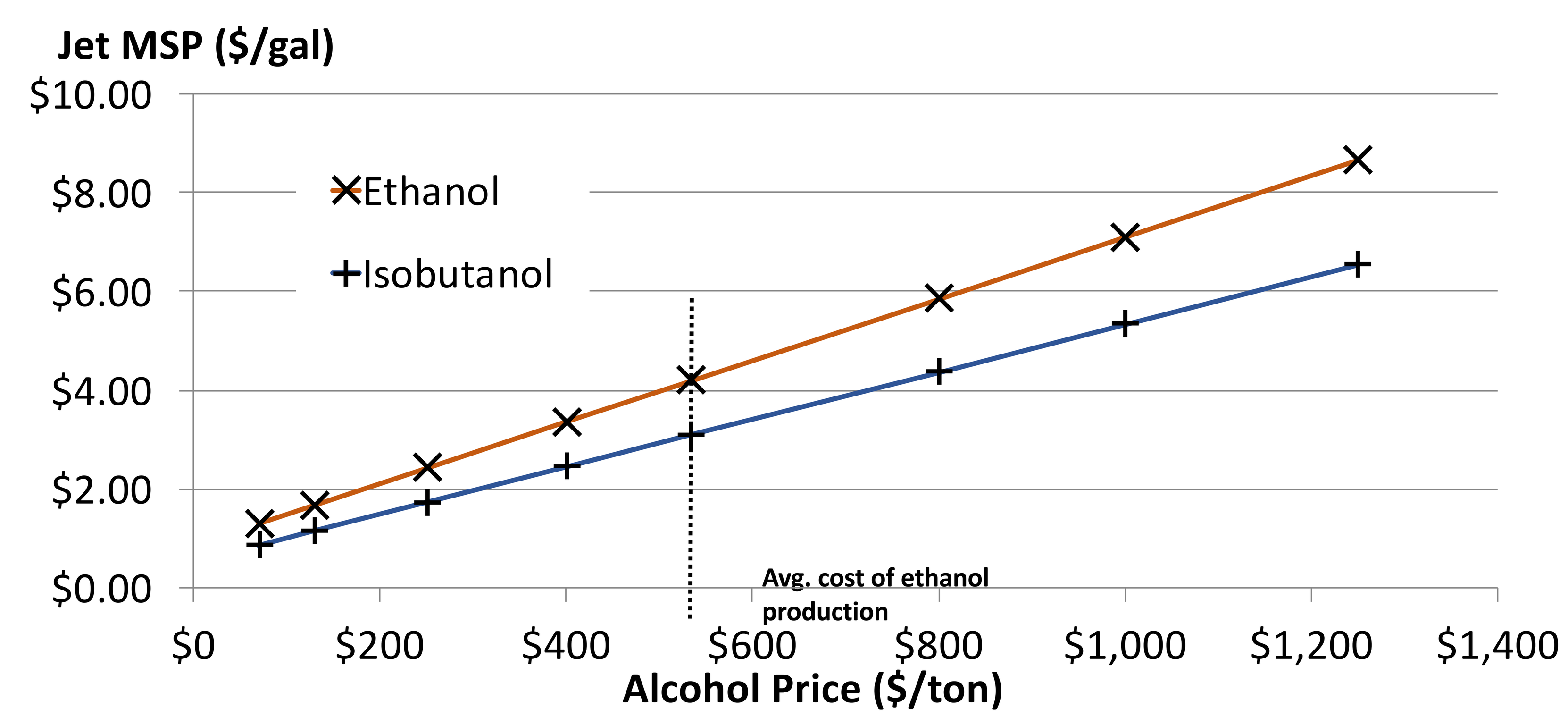
The ATJ Conversion pathway consists of an ethanol or isobutanol feedstock which is processed using dehydration, oligomerization, hydrogenation, and fractionation. The major costs for this process include capital expenses, fixed operating expenses, and energy costs (steam, nat. gas, and electricity).



Cost and Yield Data for ATJ Scenarios from a Carbohydrate Feedstock

	Ethanol Pathway	Isobutanol Pathway (low cost fermentation)	Isobutanol Pathway (high cost fermentation)
Mass Yield	0.274	0.277	0.277
Alcohols Processed (ton/day)	200	161	161
Total Capital Investment, MM$	$77.4	$55.0	$94.2
OpEx, MM$/yr	$15.8	$13.9	$18.4
Jet Fuel Production Rate, MMgal/yr	7.56	7.65	7.65
Gasoline Production Rate, MMgal/yr	1.29	3.92	3.92
Diesel Production Rate, MMgal/yr	2.26	0	0
Conversion Cost, $/gallon jet fuel	$2.84	$2.23	$3.37
Basis: 435 ton/day sugars			

Although both isobutanol or ethanol may be used to produce ATJ-SPK, the conversion process does differ considerably between them. Our models predict the selling price of the jet fuel blendstock depending on the effective price for a given alcohol. Isobutanol may be produced through proprietary advanced fermentation technologies; ethanol production is possible from conventional biorefinery methods (i.e. corn and sugar cane mills) or through advanced methods such as flue gas or biomass hydrolysate fermentation.



Lead investigator: M. Wolcott, M. Garcia-Perez, X. Zhang
Washington State University
Project manager: Nathan Brown, FAA
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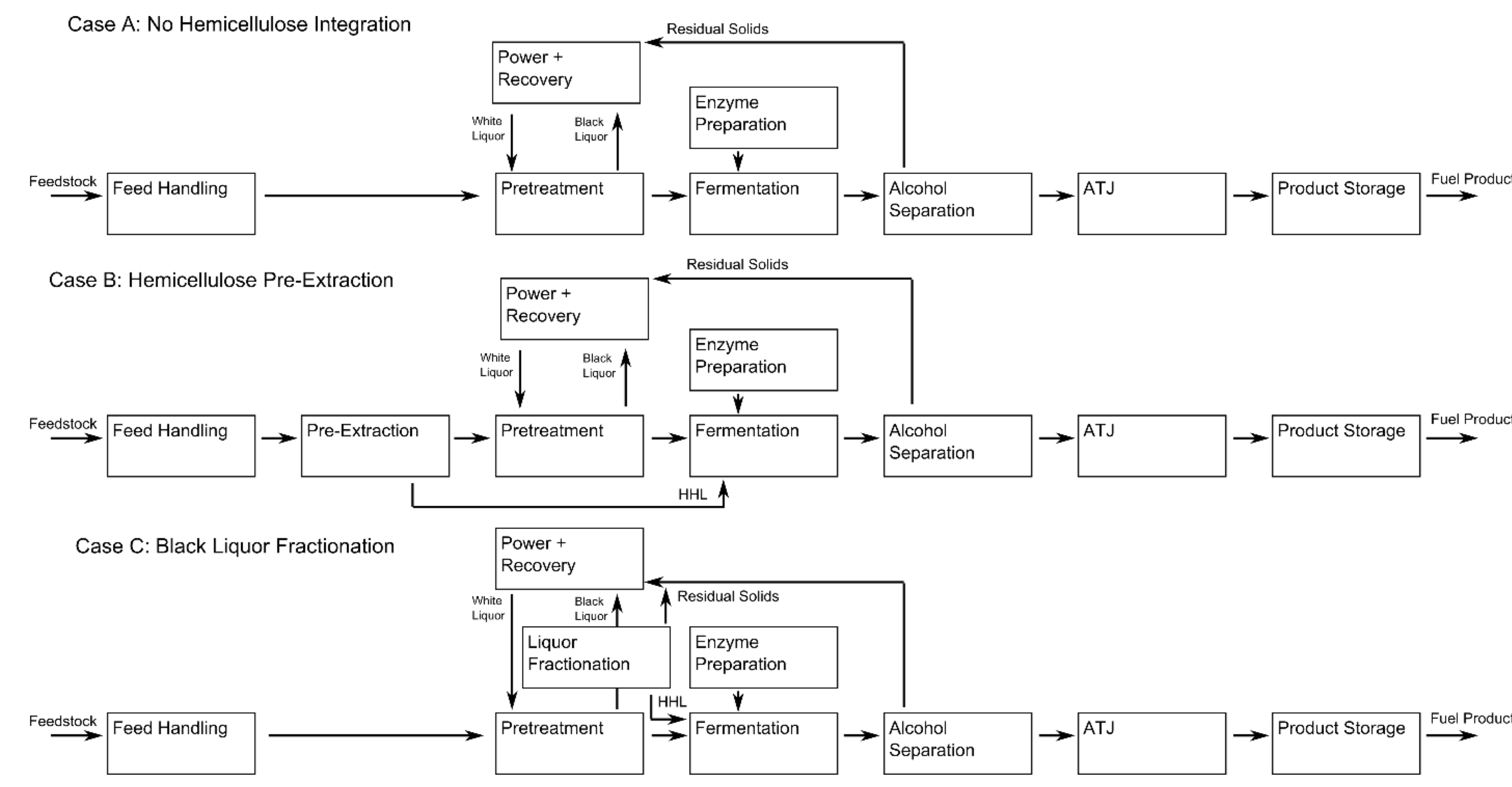
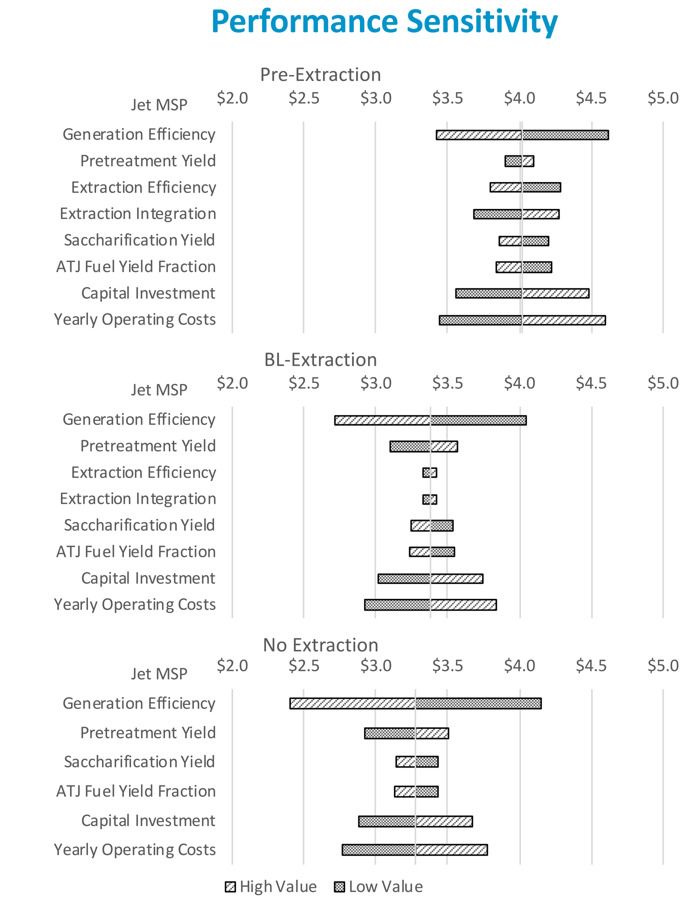
Integrated Pulp-ATJ Biorefinery Model

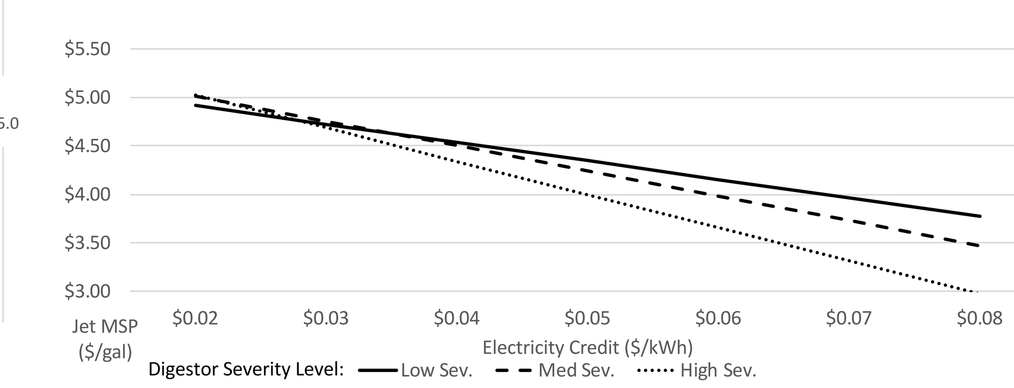
The Pulp-ATJ concept incorporates the power and recovery loop of a kraft pulp mill into a biomass pretreatment process, feeding the lignocellulosic fermentation of ethanol for ATJ conversion. Integration of these new units with the steam and electricity production of the mill's recovery boiler reduces their capital investment and energy costs. A net increase in energy production is observed, which is valued as a credit toward powering other mill operations or sold as electricity to the grid.



Preliminary Results from Pulp-ATJ Biorefinery Model



	No Extraction	Pre-Extraction	BL-Extraction
Fuels Production (gal/day)	34,643	45,275	40,849
Electricity Produced (kWh/day)	62,612	43,911	44,637
Total Fuels Yield (gal/ADT)	35	45	41
Electricity Yield (kWh/ADT)	1,503	1,054	1,071
Total Capital Investment (MM$)	$155.34	$220.95	$159.58
Total Annual Operating Expenses (MM$)	$47.25	$57.45	$49.05
Total Annual Revenue from Fuels (MM$)	$37.74	$62.85	$47.02
Total Annual Revenue from Electricity (MM$)	$26.05	$18.27	$18.57
Jet MSP $/gal	$3.95	$4.58	$3.89
1000 ADT/day scale (50% of complete facility)			



Conclusions and Recommendations

1. AJF production through Alcohol-to-Jet conversion technology is likely to see further commercial success in the near future as long as advanced fermentation technologies continue to advance.
2. Major costs facing the production of ATJ-SPK is the production cost of alcohol, capital expenses, and energy costs.
3. A kraft pulp mill partial retrofit may provide a competitive scenario for the production of AJF through alcohol fermentation. The amount of excess energy generation is a strong determining factor, however.
4. Further modeling and investigation into biomass pulp conversion and energy recovery potential is recommended to further optimize the economics of integrated biorefineries