ASCENT 1: Environmental and economic assessment of jet fuel from municipal solid waste (MSW)

Motivation and Objectives

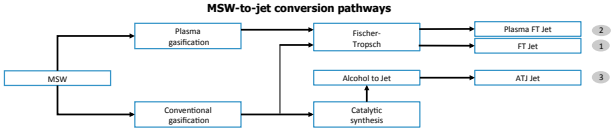
Municipal solid waste as a feedstock for alternative jet fuel:

- Offers the potential to reduce the greenhouse gas intensity of aviation
- Displaces existing waste management strategies that have high GHG emissions (US landfills)
- No additional land and water use for feedstock
- No direct competition with food production
- Low or negative feedstock cost (average landfill tipping fees in the US: ~$50/ton MSW)

The project aims to evaluate three thermochemical MSW-to-jet pathways and:

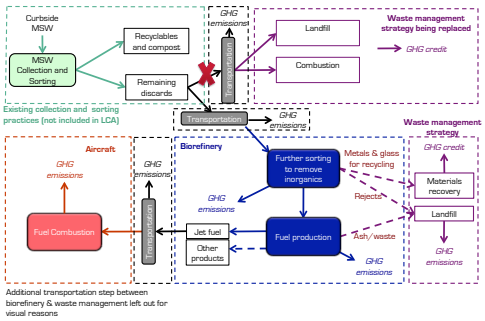
- Quantify environmental performance in terms of **lifecycle greenhouse gas emissions** by life-cycle assessment (LCA)
- Quantify economic performance (costs of production) in terms of **minimum selling price and net present value** by techno-economic analysis (TEA)
- Perform stochastic and scenario-based analysis to account for uncertainty and variability

MSW-to-jet conversion pathways



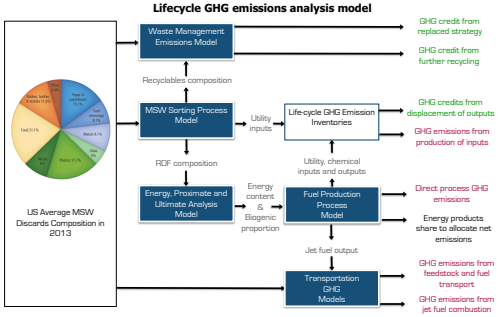
Methods and Materials

MSW lifecycle model

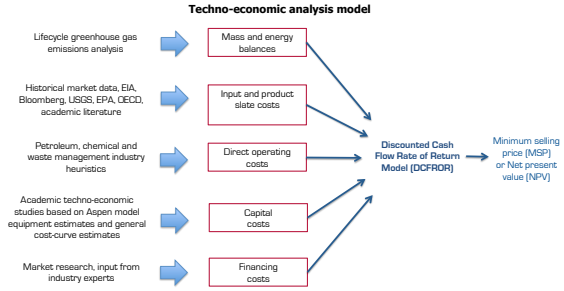


- The US average MSW composition and management statistics (from US EPA) are used to build an LCA model, which assesses the **change in the MSW lifecycle** that is induced in order to produce fuels relative to its existing lifecycle.
- The model is employed to calculate the net greenhouse gas emissions over the entire lifecycle, excluding existing collection and sorting practices but accounting for GHG credits from replacement of the existing waste management strategies as well as fuel combustion emissions attributable to the non-biogenic proportion of MSW.
- The material and energy balances for each conversion technology are estimated from literature, and also applied to techno-economic analysis to estimate costs of production, using a discounted cash flow rate of return model.
- **Monte Carlo simulations** are used to translate the uncertainty in the input parameters, captured by probability distributions, to uncertainty in the results.

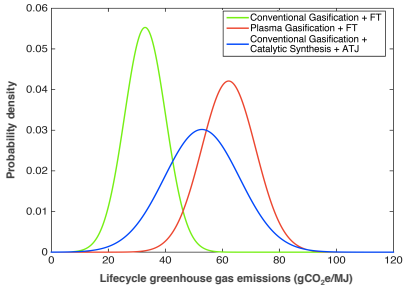
Lifecycle GHG emissions analysis model

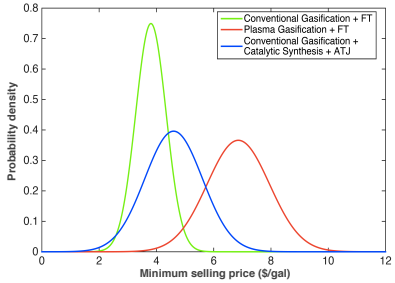


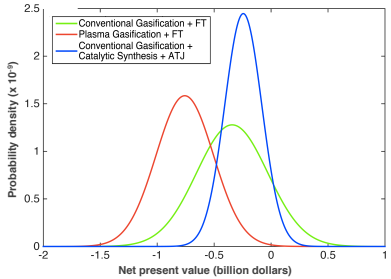
Techno-economic analysis model



Results and Discussion







	Conversion Pathway	Median	Mean	Standard Deviation
Lifecycle GHG emissions (gCO_2e/MJ)	(1) FT Jet	32.86	32.89	7.22
	(2) Plasma FT Jet	62.09	62.20	9.48
	(3) ATJ Jet	52.45	52.82	13.22
Minimum selling price ($/gal)	(1) FT Jet	3.78	3.81	0.53
	(2) Plasma FT Jet	6.75	6.86	1.09
	(3) ATJ Jet	4.52	4.60	1.01
Net present value ($B)	(1) FT Jet	-0.339	-0.342	0.312
	(2) Plasma FT Jet	-0.751	-0.758	0.252
	(3) ATJ Jet	-0.245	-0.244	0.163

- The median lifecycle GHG emissions of the three MSW-derived jet fuels are lower than that of conventional jet fuel (87.5 gCO_2e/MJ). These results are most sensitive to MSW composition (non-biogenic proportion of MSW), fuel yields, recycling rates, credit from the replaced waste management strategy and utility requirements for the conversion process.
- The median minimum selling price for all three pathways are above the current price of jet fuel ($1.07/gal). These results are sensitive to capital investment, choice of discount rate, fuel yield, feedstock cost and recyclable scrap metal prices. If the **social opportunity cost of capital** (3.2%) were used as the discount rate instead of 15%, the **MSPs would be $1.81/gal, $2.73/gal and $1.55/gal** for the three pathways respectively.

Preliminary results – Please do not cite or quote.

Conclusions and Next Steps

All three MSW-to-jet pathways **offer an environmental benefit** compared to conventional jet fuel but the costs of production are higher. Therefore, policy instruments such as capital subsidies, de-risking via loan guarantees and offtake agreements, and carbon tax/credits are required to ensure economic feasibility. Due to **significant parameter uncertainty**, stochastic analysis is necessary to assess and compare the three pathways comprehensively.

This work will be published as a journal paper and master's thesis. The modeling capabilities developed for this work **(stochastic MATLAB models of LCA and TEA)** will be employed in future work, including further exploration of evolvement of GHG emissions and costs of production over time, extension of the model to account for spatial variation within the US by NERC region and/or state, and a case study on MSW as alternative fuel feedstock in developing countries.

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