Corn-Based Bioethanol for Sustainable Aviation Fuel (C-BioSAF)

CHBE Team 8

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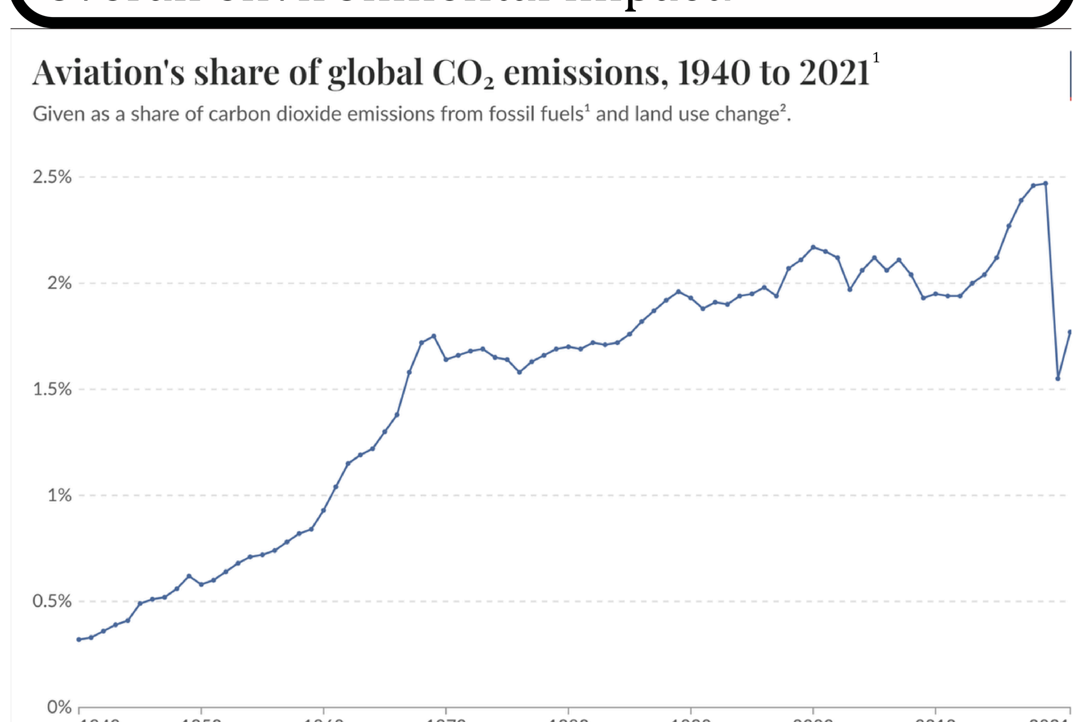
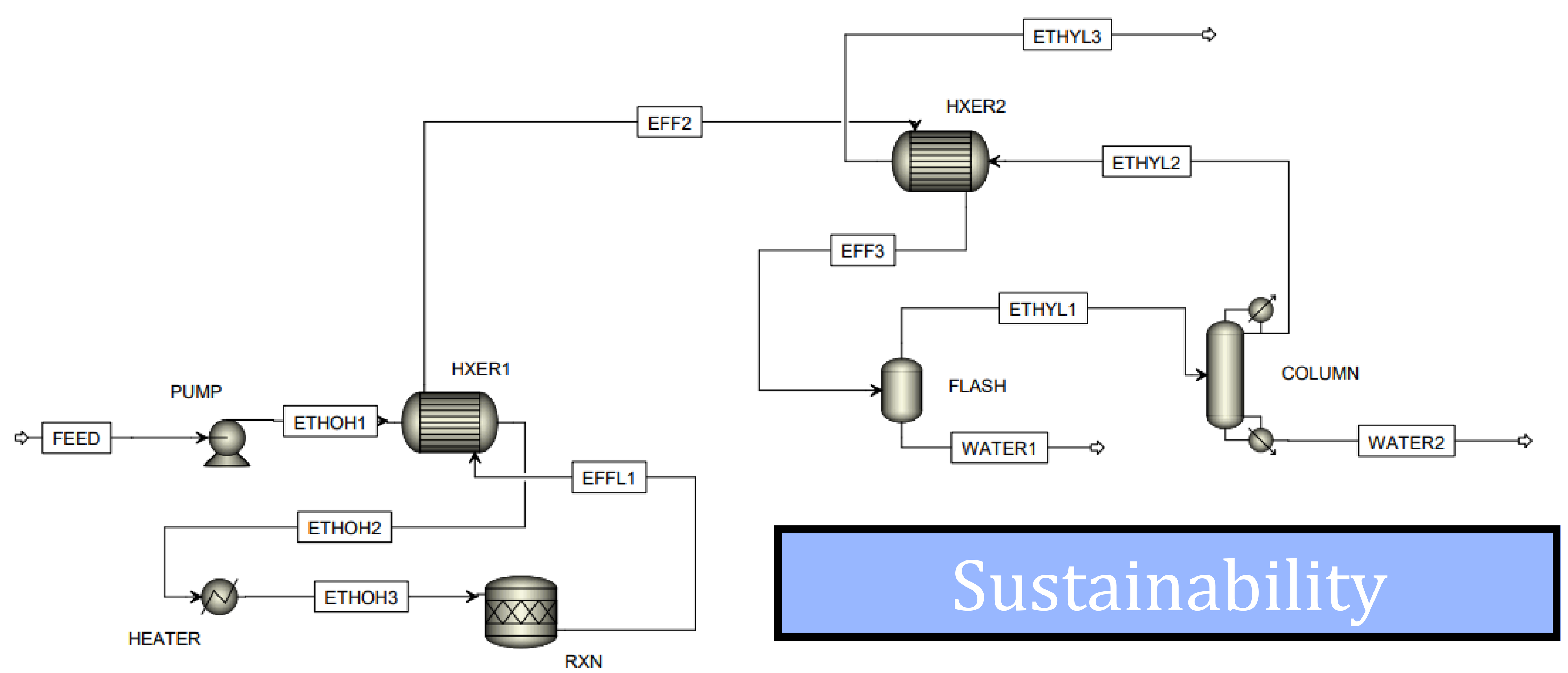
Project Overview

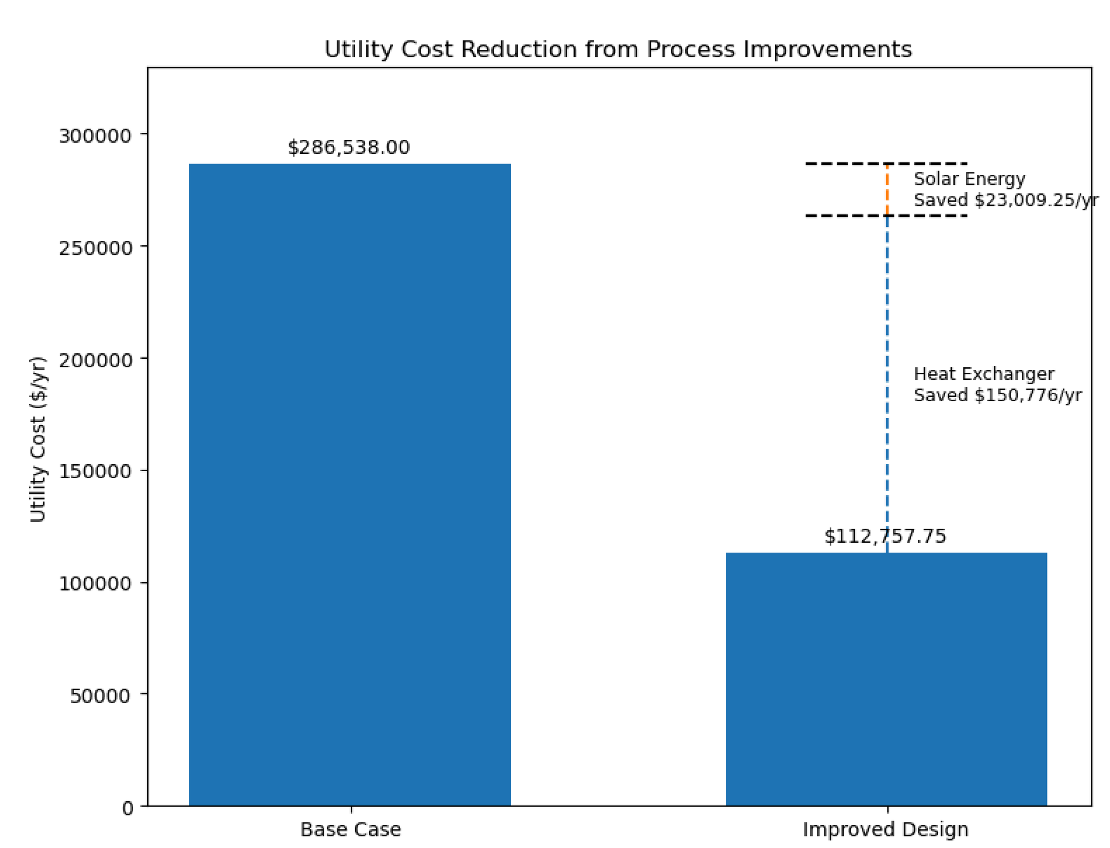
This project investigates the bioethanol to sustainable aviation fuel (SAF) process, with an emphasis on the sustainability of the dehydration of bioethanol. We aim to examine the energy and material consumption of the whole process, and explore avenues to make it more sustainable. In particular, we evaluate the physical and economic feasibility of incorporating solar power, additional heat integration, and methods of reducing and repurposing the waste water released from the process.

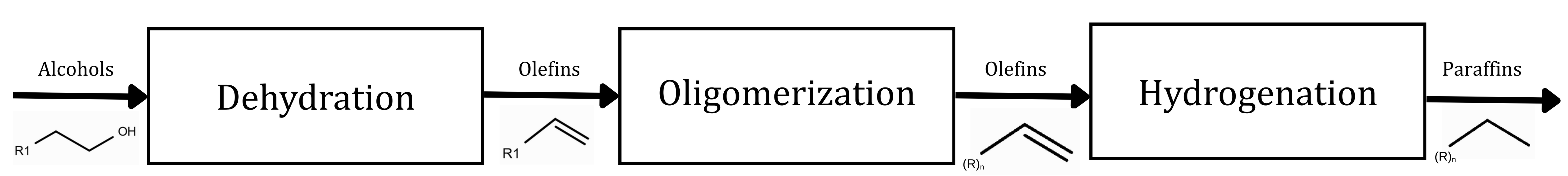
Current Status

At present, most jet fuel is produced through crude oil refinement. This process is intensive in the consumption of fossil fuels. Aviation in particular accounts for roughly 2.5% of global fossil fuel consumption, a substantial increase from the 1940s.[1] Producing aviation fuel is incredibly taxing for the environment in the form of air and water pollution.[2] The alcohol to jet (ATJ) process provides avenues for improving the sustainability of aviation fuel production. This pathway offers a scalable solution for advancing long-term decarbonization goals within the aviation industry. Current analyses indicate that SAF produced from ethanol can achieve approximately 15% lower carbon intensity compared to conventional jet fuel sources, making it a promising option for reducing aviation's overall environmental impact.









Sustainability

Carbon Emissions

- Base case: 238 metric tons CO2/yr
- With 55% solar: grid + solar emissions = 117 metric tons
- 50.8% reduction in electricity-related CO2 emission

Water

- Base case steam demand: 3.37 KLB/H LP steam → 4,043 lbs/day blowdown water loss
- Improved design reduces steam to 1.26 KLB/H → 1,508 lbs/day blowdown, a 63% reduction.

References

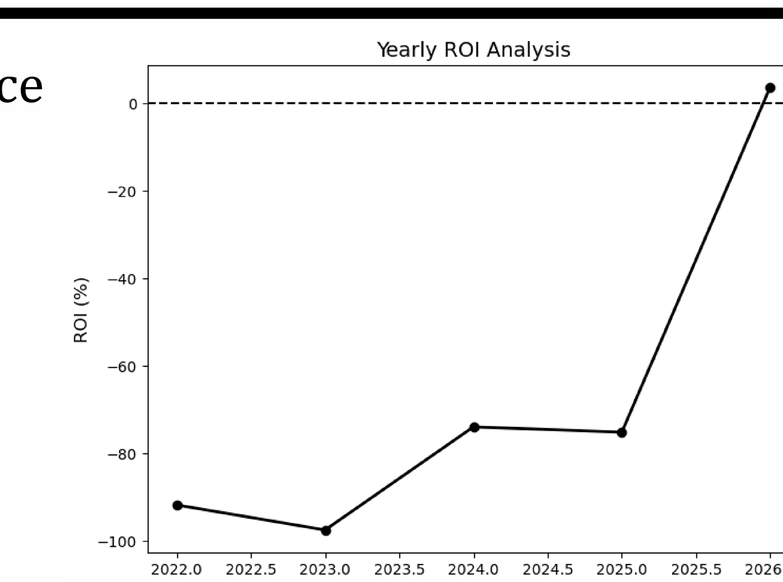
1. Ritchie, H. What Share of Global CO2 Emissions Come from Aviation?. *Our World in Data* 2024.
2. EcoServants. Petroleum and Oil: Extraction, Refining, and Environmental Impact | EcoServants®. Ecoservantsproject.org. https://ecoservantsproject.org/petroleum-and-oil-extraction-refining-and-environmental-impact/.
3. Geleynse, S.; Brandt, K.; Garcia-Perez, M.; Wolcott, M.; Zhang, X. The Alcohol-to-Jet Conversion Pathway for Drop-In Biofuels: Techno-Economic Evaluation. ChemSusChem 2018, 11 (21), 3728–3741. https://doi.org/10.1002/cssc.201801690.
4. U.S. Energy Information Administration. U.S. Jet Fuel Consumption in 2023 Remained Below the Pre-Pandemic High. Today in Energy 2024, July 8. https://www.eia.gov/todayinenergy/detail.php?id=62443.

Process Specifications

		Flow Rate (tons/day)	Composition
Feed	Ethanol	225.84	0.955
	Water	4.16	0.045
PFR	Ethanol	22.58	0.051
	Ethylene	123.77	0.462
	Water	83.64	0.486
Flash Drum: ETHYL1	Ethanol	1.57	0.01
	Ethylene	121.66	0.98
	Water	0.75	0.01
Flash Drum: WATER1	Ethanol	21.02	0.089
	Ethylene	2.12	0.015
	Water	82.89	0.9
Column: ETHYL3	Ethanol	0	0
	Ethylene	117.9	1
	Water	0	0
Column: WATER2	Ethanol	1.57	0.16
	Ethylene	3.76	0.14
	Water	0.75	0.71

Economic Analysis

- Design improvements reduce non-feedstock operating expenses by 14.47%
- Market pricing of ethanol heavily impacts return on investment and company economic viability



Conclusion

This process produces roughly 48.3 tons of jet fuel per day. While there were significant considerations regarding the carbon emissions of the process, the yield is small compared to the fuel needs of airports such as BWI. Our yield can only support 2.25% of daily operations at BWI, so further scale up is needed. Variability in ROI highlights the effects of volatile fuel and ethanol prices. Ethanol feedstock costs are a major obstacle in current process profitability. Process improvements and solar energy can be implemented to reduce operating costs, while still obtaining 100% pure ethylene product required for later steps in ATJ.