Thesis Project Portfolio

Supercritical Production of Biodiesel from Waste Cooking Oil

(Technical Report)

Complementary Pathways to Decarbonization: The Social and Economic Implications of Integrating EVs and Renewable Fuels in the U.S. Auto Industry

(STS Research Paper)

An Undergraduate Thesis

Presented to the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Felipe De Pinho

Spring, 2025

Department of Chemical Engineering

Table of Contents

Executive Summary

My technical work on supercritical biodiesel production and STS research on economies of scale and government policy initiatives for green transportation share a common goal: advancing sustainable fuel alternatives. While my technical project explores an innovative production pathway for biodiesel, my STS research examines how policy frameworks can accelerate the adoption of such technologies. This STS research also sets technologies in an economies-of-scale framework, analyzing all the factors that go into the successful implementation of new technologies. Together, these complementary projects provide insights into both the technical and socio-political and economic dimensions of energy transitions.

Traditionally, biodiesel is made through catalytic pathways, which involve expensive feedstocks and additional purification processes. However, biodiesel can be made through a supercritical pathway, which does not require expensive catalyst purchasing and can also be done with lower-quality feedstock. This capstone project delves into this supercritical transesterification process and proposes a fully scaled plant operation that produces ~10,000 tons of biodiesel a year. Overall, this project exemplifies an additional pathway for biodiesel manufacturing that has the potential to lower input costs in comparison to conventional biodiesel manufacturing methods.

My STS research advocates for a dual-approach strategy to transportation decarbonization that leverages both electric vehicles and renewable fuels like biodiesel. The paper challenges the dominant narrative that electrification alone represents the optimal path to sustainable transportation, arguing instead that policy frameworks should support complementary solutions. Through analysis of economies of scale, infrastructure requirements, and socio-economic factors, I demonstrate how EVs and renewable fuels can address different segments of the transportation

sector more effectively than a single-technology approach. The research identifies policy blind spots that favor electrification while overlooking various social, economic, and environmental factors, like increasing rare earth metal demand. By examining both approaches with an economies-of-scale framework, this paper exemplifies the pros and cons of the dual approach to decarbonizing the transportation sector.

Working simultaneously on both projects provided very valuable insights for not only the ability that engineers have to create change in the world, but also the vast network of factors that play into how technologies succeed. The technical work revealed engineering challenges of alternative fuel production, while the STS research showed how policy frameworks determine which technologies succeed in markets, and how certain technologies can reach economies of scale. This integration taught me that successful energy transitions depend on the interplay between technological innovation, policy design, and social acceptance, and not just technical feasibility. By bridging engineering and policy perspectives, I've developed a comprehensive approach to sustainability challenges that considers both technical solutions and their implementation in society.