Thesis Project Portfolio

PRODUCTION OF SUSTAINABLE BUTANOL BIOFUEL FROM CORN STOVER

(Technical Report)

A SOCIOTECHNICAL ANALYSIS OF BIOFUEL POLICY DEVELOPMENT

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of 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

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Spring, 2024
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Sociotechnical Synthesis

Introduction:

This portfolio's technical and STS projects both encompass investigations into a booming alternative energy source, biofuels. Biofuels are a source of liquid fuel that derive from renewable sources, such as various plant materials or vegetable oils. The technical project aims to improve the production of a newer, more energy-dense and engine-compatible biofuel, butanol, from a nonedible feedstock, corn stover. The STS project analyzes the development of U.S. biofuel policy in the last two decades, and how its rhetoric, often over-idealistic mandates, and inevitable political influence translates to real-world execution.

Technical Project:

The purpose of the technical project is to provide a simulated technical design with accompanying safety and economic analyses of a biobutanol plant capable of producing 57 million kilograms (19 million gallons) of butanol each year from corn stover waste. Butanol produced at this plant would be blended into gasoline to reduce reliance on fossil fuels while improving upon the shortcomings of current gasoline additives. Corn stover, a second-generation feedstock, helps improve the sustainability of the project by using a waste stream while reducing problematic reliance on feedstocks that would otherwise go towards food production.

The simulated design involves three main process blocks: acid pretreatment, fermentation, and separations. First, corn stover is milled and broken into digestible sugars using acid hydrolysis. Then, Acetone-Butanol-Ethanol fermentation using *Clostridium* bacteria turns these sugars into the desired butanol product. The remaining corn waste combines with a high value side product, calcium monohydrogen phosphate, to be sold as a nutritious animal feed supplement. Acetone and ethanol, the other products produced during fermentation, are

subsequently combusted to generate steam after a separation process that isolates the fuel-grade butanol.

The economics of this process indicate an IRR of 13.9% and a net present value of around $1.52 billion. This indicates that this investment could be prudent. The team, however, recommends that more research be done before a final investment decision is made. Several uncertainties remain surrounding the animal feed pricing, which is especially important given that it is the team's main revenue driver for the plant.

STS Project:

This portfolio's STS project narrows in on the real-world development and implementation of biofuels. In recent years, there have been specific unintended environmental and socioeconomic consequences of widescale biofuel production. This project aims to identify the source of these consequences through analysis of policy that has ultimately set the rate of biofuel production. Specifically, it analyzes the development of the Renewable Fuel Standard (RFS) as authorized by the 2005 Energy Policy Act and expanded under the Energy Independence and Security Act of 2007. The RFS requires minimum production volumes of renewable fuel each year to reduce the U.S. heavy reliance on petroleum-based transportation fuel. Not only does this project examine the RFS itself, but it also presents evidence from two relevant congressional hearings from the Senate Committee on Energy and Natural Resources about the RFS from two different stages of the policy's development. This project uses Pinch and Bjiker's Social Construction of Technology (SCOT) framework to parse together how social groups represented (or not represented) in these congressional conversations have influenced biofuels' trajectory.

The findings from this project reveal the various social and political motivations present in biofuel congressional hearings that affected the nature of the RFS policy itself. The research uncovers how certain groups, such as state and federal levels of government, the petroleum industry, midwestern farming associations, climate researchers, and environmental groups have fought for varying levels of caution with biofuels in these congressional conversations. Misrepresentation of environmental groups, certain state governments, and climate researchers at earlier conversations reflect misguided and overconfident goals addressed in the first iteration of the RFS policy. Through SCOT, this research delves deeper into the social implications of policy that involves the implementation of new alternative energy technology.

Conclusion:

Because the team completed all aspects of the technical project entirely in simulation environments, the STS project provided a means for connecting this work to a societal reality. Most of the team's concerns throughout the year were highly technical or hypothetical. However, this STS project helped improve the understanding of what makes biofuel adoption and implementation environmentally effective and sociotechnically just. This is extremely relevant for theoretical, real-world discharge of the team's technical work. This STS project provided a means for a thorough understanding of the presently proven implications of biofuels, such as its true renewability, cleanliness, water usage, and fragility within the market. This knowledge tremendously helped influence the technical team's decisions throughout the economic, environmental, and safety analyses. The SCOT perspective also helped keep highly technical design decisions consistently intertwined with some of needs and concerns of various social groups identified within the STS research.