Thesis Project Portfolio

Production of Sustainable Butanol Biofuel from Corn Stover
(Technical Report)

Ethanol Biofuel in the Context of Technological Momentum
(STS Research Paper)

An Undergraduate Thesis

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Bachelor of Science, School of Engineering

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Socio-technical Synthesis: Alcohol Biofuels

My technical design and STS project are connected by alcohol biofuels and the potential for their improvement. Ethanol is currently the most common alcohol biofuel in the United States and continues to be used despite the discovery of better biofuel alternatives. The technical and STS portions of my thesis address this in different ways. The STS portion analyzes the rise of ethanol biofuel and its current resistance to change despite the alternatives. The technical portion is a design of a chemical process that produces butanol, one such better alternative biofuel, from corn waste via fermentation. Although the two parts of my thesis tackle different aspects of alcohol biofuel production and use, the STS analysis can be used to inform the production and implementation of the alternative biofuel put forth in the technical design.

The technical portion of my thesis is a chemical plant design producing 57 million kilograms of 99.99% purity butanol each year from a feedstock of corn stover. This is accomplished via four process blocks: (1) milling, (2) acid pretreatment, (3) Acetone-Butanol-Ethanol (ABE) fermentation, and (4) separations. Milling grinds corn stover to a digestible size. Acid pretreatment hydrolyzes the cellulose from corn stover into fermentable sugars while producing a high-value animal feed by-product. ABE fermentation uses clostridium bacteria to convert fermentable sugars into butanol and other metabolites. Finally, separations removes the butanol from the other compounds exiting the fermentation block. The technical report includes the design of all major process equipment, scheduling, a safety report, and a full economic analysis. The plant design was not recommended for immediate investment citing a need for more research and development of key design elements.

The STS portion of my thesis uses Thomas Hughes' socio-technical framework of Technological Momentum to analyze the rise of ethanol biofuel. Ethanol biofuel rose from a new technology that was heavily influenced by society to a position of vast social influence, stability, and resistance to change. The mechanisms of building momentum analyzed in the STS report include (1) organizational bureaucracy, (2) special-purpose processes and machines, and (3) enormous physical structures. The goal of this research was to present a full analysis of the building of technological momentum for ethanol biofuel, thereby showing how ethanol has gained its position of stability and influence over the biofuel landscape and society as a whole.

Working on both of these projects simultaneously allowed me to realize the societal challenges that butanol may face even after a successful technical design. Even if butanol biofuel with ABE fermentation from the technical design is recommended for further investment, it is possible that replacing a stable biofuel technology like ethanol may be challenging. The momentum built by ethanol biofuel thus potentially makes an investment in my butanol technical design even riskier than anticipated. Working on these two projects simultaneously also allowed me to see two distinct sides of a biofuel technology. The technical design showed me just how complex and intricate a chemical design can be, as well as the many layers of planning needed to make a viable product. The STS portion showed me the importance of the interaction between a biofuel technology and society. Putting both of these sides together, I was able to develop a better understanding of the many facets of both novel and existing biofuels.