Thesis Project Portfolio

Sustainable Utilization of Whey By-Product For the Production of Biobutanol

(Technical Report)

Analysis of Barrio Logan's Biodiesel Plant Failure

(STS Research Paper)

An Undergraduate Thesis

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Executive Summary

Both my technical and STS research papers are based around the implementation and utilization of relatively new technologies that are focused on sustainability within the energy sector. The technical report details the process and economic viability of a biofuel plant converting a waste stream of a nearby yogurt manufacturing plant in Twin Falls, Idaho. Comparatively, the STS research paper investigates the sociotechnical system created between a biofuel plant and the surrounding community via the case study of New Leaf Biofuels in Barrio Logan. Together both papers aim to asses whether the technology of biofuels is worth investment, research, and development and how to properly implement these technologies in the future.

The increasing demand for renewable energy sources, along with the environmental issues tied to acid whey disposal from Greek yogurt production, creates a promising opportunity for sustainable innovation. This technical report presents the design of a continuous-operation processing plant that transforms acid whey into dry whey protein powder and biobutanol. The facility integrates multiple unit operations, including ultrafiltration, reverse osmosis, spray drying, fermentation, flash separation, depth filtration, and solvent recovery. Ultrafiltration and reverse osmosis act as essential pretreatment stages, concentrating proteins and lactose for downstream processing. The spray drying system then removes moisture from the protein-rich retentate, yielding a shelf-stable, commercially viable whey protein powder. Fermentation employs *Clostridium acetobutylicum* to convert lactose to alcohol products via a two-stage anaerobic process: acidogenesis, which generates acids like butyric and acetic acid, followed by solventogenesis, where intermediates are converted into acetone, butanol, and ethanol. Bioreactor conditions are tightly regulated to maximize butanol yield, with a continuous seed train feeding the system with bacteria to enhance productivity. After fermentation, the broth undergoes flash separation to vent CO_2, followed by depth filtration to eliminate microbial biomass. A five-column distillation setup then isolates each solvent product at high purity, enabling recovery of market-grade acetone and butanol while minimizing energy use and waste. Economic projections show that the plant will achieve breakeven within five years and generate sustained profit over a 20-year operational span. Interestingly, most of the revenue is driven by the dry whey protein rather than biobutanol, contrary to early expectations. Even so, the findings support the plant's construction, with further research and optimization recommended to improve overall efficiency and yield.

The technical report provides evidence to support the economic viability of sustainable biobutanol production, while the accompanying STS (Science, Technology, and Society) research paper explores the broader sociotechnical dynamics that influence the success or failure of implementing a biofuel facility. The STS paper presents a case study on New Leaf Biofuel, a company that converted used cooking oil into sustainable biofuels in the community of Barrio Logan, California. This case was analyzed through the framework of Actor Network Theory (ANT), which enables a nuanced evaluation of the various human and non-human "actors" involved in the sociotechnical network—including the company, local residents, policymakers, regulatory bodies, and environmental infrastructure. The research drew upon a combination of literature review, government documentation, and formal news reports to identify key tensions within the network. It became clear that a significant misalignment existed between the objectives of New Leaf Biofuel and those of the Barrio Logan residents. While the company aimed to advance environmental sustainability and economic growth through renewable fuel production, community members expressed concerns over environmental justice, zoning regulations, and the increased industrial presence in a historically underserved neighborhood. These conflicting interests ultimately disrupted the cohesion of the network, leading to resistance and contributing to the system's

failure. Through the lens of Actor Network Theory, the study underscores that the success of a sociotechnical system hinges not only on technological innovation or economic feasibility, but also on the alignment of values, goals, and power dynamics among all actors involved. The findings from this case study serve as a cautionary tale, emphasizing the importance of early and continuous stakeholder engagement, transparent communication, and equitable decision-making in the deployment of sustainable technologies. These insights are especially relevant when considering future implementation of biobutanol facilities, which must navigate similar environmental, economic, and social complexities.

By completing my STS research paper, I gained a deeper understanding of how to implement biofuel technologies in modern day society. This in turn inspired me to create a more robust and effective technical process to promote the growth and usage of biofuels. Completing the technical report gave me an appreciation for the hard work and research that goes into developing large-scale processes. The STS research paper showed that despite the biofuel process being marketable, the implementation of biofuel technologies are a large factor in the successfulness of the technology as a whole. Working on both the technical report and the STS research paper has provided with evidence for how biofuels can operate within the food space and the larger energy sector. Ultimately leading to gain a deeper understanding for how these technologies can exist with large infrastructural and social frameworks.