Thesis Project Portfolio

Supercritical Production of Biodiesel from Waste Cooking Oil

(Technical Report)

Environmental, Social and Economic Factors Affecting the Performance of the Malaysian Biofuels Market

(STS Research Paper)

An Undergraduate Thesis

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In Fulfillment of the Requirements for the Degree

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Maya Reese

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Department of Chemical Engineering

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Sociotechnical Synthesis

My STS project and technical design both explore the production of biodiesel and its market performance. Although biofuels have the potential to reduce greenhouse gas emissions from the transportation sector, they are frequently more expensive than petrochemical based fuels. The STS project analyses the underperformance of the Malaysian biofuel market which relies primarily on first-generation feedstocks like palm oil. Biofuels produced from first generation feedstocks have come under scrutiny due to competition with food crop resources and environmental concerns about land use changes. The analysis of these issues contributed to the motivation for the design of a process to produce biodiesel from a second generation feedstock. The technical section of my thesis is the design of a chemical process that produces biodiesel from waste cooking oil (WCO). This addresses some of the issues uncovered in the STS analysis by utilizing a lower-quality waste stream feed that does not compete with food resources and land.

The technical project is the design of a supercritical process that produces approximately 9,500 t/yr of B100 biodiesel from WCO. The WCO is converted to fatty acid methyl esters and glycerol through two reaction pathways in a plug flow reactor. One pathway is the direct transesterification of WCO. The other pathway is the hydrolysis of WCO and the subsequent esterification of free fatty acids. The reactor operates at supercritical methanol conditions to eliminate the need for expensive catalysts and allow for the use of a lower quality feedstock. Downstream separation processes recover unreacted methanol and a propane co-solvent to lower raw material costs. Finally, the biodiesel and glycerol are purified to meet ASTM D6751-24 and USP standards respectively. The technical report also includes a plant construction timeline, social, safety and environmental considerations, and an economic analysis. The construction of a

pilot plant was recommended to verify the validity of the kinetic data and conversion assumptions before moving forward with investment in the full-scale design.

In my STS research, I use actor network theory, developed by Michel Callon, Bruno Latour, and John Law, to analyze Malaysian biodiesel market performance. Although Malaysia has an abundance of biomass feedstock, the country has failed to meet many of the goals outlined in the National Biofuel Policy. Using the subconcept of translation, the STS report analyzes how biodiesel company practices and weakened bonds between the Malaysian government and the European Union contributed to challenges during enrollment and mobilization. Environmental concerns, negative biofuel media, and the move to domestic biodiesel consumption all threaten the stability of the Malaysian biofuel network.

By working on both projects simultaneously, I developed a deeper understanding of the relationship between technical design, society and the environment. The results of the STS project helped inform technical decisions about feedstock type, reactor conditions, and process economics. I also learned how the success of a technology is dependent on many interconnected human and non-human actors. The complexity of stakeholder relationships can make it challenging to predict the outcomes of investment in a technology. Ultimately, working on both projects showed how engineering design can be used to address societal concerns and how society can influence technological development.