THESIS PROJECT PORTFOLIO

Production of Biodiesel from Algae

(Technical Report)

Societal Players that Contributed to COVID-19 Vaccine Trust

(STS Research Paper)

An Undergraduate Thesis

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TABLE OF CONTENTS

This capstone portfolio contains two research topics: a technical research component and an STS research component. The technical research aims to design a production facility for biodiesel through algae cultivation. This research can help illustrate the economic feasibility of a large-scale algae biofuel production facility, as well as address the technical challenges in designing an end-to-end process to extract energy from biomass. The STS research aims to analyze how the interactions and relationships between different key social groups impacted the U.S. public's general hesitancy toward the COVID-19 vaccine. The STS research can help identify what factors in play caused the general lack of trust and confidence in medical authorities amidst the global pandemic. The themes of the two research topics are loosely coupled with the theme of potential career paths for a chemical engineer. Algae biofuel is a growing field for both the oil-gas industry and the renewable energy industry. These industries, coupled with the pharmaceutical industry, are all fields in which chemical engineers have foundational training.

In the technical research, the main products sold in the designed production facility are pure biodiesel (fatty acid methyl esters, FAME) and food-grade glycerol. The annual production for both of these products is 4.5 million gallons of biodiesel and 970,000 kg of glycerol. The production process can largely be split up into four sections: 1) algae cultivation, where algae are grown in open raceway ponds, 2) lipid extraction, where the necessary oils are isolated from the cultivated algae, 3) reaction, where the removed oils are reacted through two separate schemes to convert the oils into desired fuel products (FAME) and side products (glycerol), and 4) refinement, where each of the products is purified to saleable specifications.

Algae cultivation occurs in 65,120 open raceway ponds, which allow algae to grow in recirculated pond water over a period of 10 days. After enough algae density is measured, the

algae are separated from the water using a dissolved air flotation unit, which conveniently allows the water to be recycled back into the raceway ponds. After enough water is separated from the algae through drying steps, it is extracted for lipids using a hexane decanter. The extracted lipids are now sent to the reaction phase. The first step is the acid esterification step, which converts fatty acids into FAMEs. The second step is the base transesterification step, which converts triglycerides into FAMEs. The result is the oils are now converted into FAME, ready to be purified down to specifications. Crude glycerol is also produced as a side product of base transesterification. The purification process requires different separation techniques, such as distillation columns and flash columns.

In the STS research, the aim of the project was to analyze the interactions between key social groups in impacting the general hesitancy toward the COVID-19 vaccine. The social groups identified were anti-vaccine groups, private citizens, pharmaceutical companies, and regulatory agencies. Each group was defined, and the motivations for their actions in the midst of the pandemic were discussed.

Anti-vaccine groups are described as any group or select few individuals who have a strong interest in promoting and spreading anti-vaccine beliefs by questioning the safety, efficacy, and validity of vaccines. They have the most obvious impact of hurting the general trust that the public has towards the COVID-19 vaccine. Private citizens are any other individuals that do not immediately identify themselves as a part of the anti-vaccine group. Pharmaceutical companies developed the COVID-19 vaccine in record time due to several different factors ranging from the flexibility of the technology, luck, and cooperation, but this incredible speed to market was also what raised suspicion in the public. Regulatory agencies also played a role in

exacerbating public distrust in the COVID-19 vaccine by announcing the regulatory flexibility they exercised when developing the vaccine.

Through the coupled capstone research project, I was able to expand my knowledge on two chemical engineering topics that are relevant to my interests. The technical research was a challenging team assignment, while the STS research demanded more individual effort. Each presented its own unique difficulties and has developed my knack as an engineer in different ways.