Thesis Project Portfolio

Microalgal Production of Biodiesel and Lutein

(Technical Report)

The societal and environmental challenges associated with the production of biofuels

(STS Research Paper)

An Undergraduate Thesis

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Executive Summary

The obstacle standing in the way of modern society is climate change. This isn't a new problem, but it poses a significant challenge to humanity because it demands uncomfortable changes to our lifestyles that the majority of people will not commit to. For this reason, technological advancement provides a way for society to integrate more sustainable alternatives into their lifestyles without having to make too many sacrifices to reduce global warming. The motivation for the technical portion of this undergraduate thesis stemmed from this idea and the aim was to design a novel process to produce biofuels from algae to help society transition off of fossil fuels more comfortably. From this, the STS portion of this undergraduate thesis is an investigation of the challenges that biofuels face with regards to the integration with society. Biofuels have been an alternative fuel source for the last century, but only a few instances of their widespread production have occurred, so this research was designed to inform on the other challenges, outside of the technological, that exist for implementing biofuels into society. The union of these two investigations provides a more complete understanding of what is required to implement biofuels to facilitate humanity's transition off of fossil fuels.

The technical research report gathers information from scholarly sources to theorize a method to produce biodiesel from *C. vulgaris* algae in an economical fashion by co-producing a high value nutraceutical called lutein. If a method to produce biofuels efficiently and at low cost is conceived, technological innovation can begin to occur to realize those theories. Therefore, the aim of this research is to foster further thought and development towards cost-effective methods for producing biofuels by highlighting key areas of difficulty in this process. Finally, an economic analysis of the project was also performed to provide insight into what areas of the process need innovation and improvement to make the project economically feasible.

It was found that the proposed theoretical process of coproducing biodiesel and lutein was not economically feasible for a variety of reasons. Firstly, current dewatering technology poses too large of a capital investment to allow a large-scale operation to recoup the initial investment over the life of the plant. Second, the use of harmful solvents provides an environmental and safety risk that also makes waste treatment alone outweigh all revenues gained. By finding safer solvents that perform similarly and also constructing an on-site waste treatment plant, the process may be able to make some yearly profit as long as there is sufficient solvent recovery and recycling. Finally, the costs of producing biodiesel would be better offset by revenues from an even higher value side product. Lutein was found to make up a much smaller portion of the revenues than expected, so either using genetically modified algae to increase the amount of lutein produced, or producing other higher-value products such as squalenes for vaccines may make producing biofuel more economically viable.

The STS portion of this undergraduate thesis seeks to understand the challenges associated with the implementation of biofuel production with society. Even if the technology to produce biofuels becomes cost-effective, engineers are still responsible for understanding the social implications of technology. Therefore, two case studies of biofuel projects affecting local communities and the environment, one in Mexico and one in Brazil, are used to portray some of the challenges associated with implementing the sustainable production of biofuels in society. Furthermore, the review of some policies on biofuel production illustrate the effect that legislation can ultimately have on society when biofuel projects are not adequately monitored or regulated.

The case studies on biofuel projects provided ample insight into the societal and environmental challenges that accompany endeavors to produce biofuels. First, care must be

taken and local experts/authorities must be consulted with regards to the environmental impact that the cultivation of biofuel feedstocks as well as land clearing can have on the local ecosystem. Second, traditional livelihoods must not be worsened and food security must be maintained (especially when there is high incentive to grow biofuel feedstock and not food crops). Finally, proper oversight and legislation control must be put in place by both federal and international bodies so as to prevent companies and regulators from disregarding adverse consequences with the intentions of upholding globally defined sustainability standards.

With both the technological innovation in the production of biofuels and the care taken to implement biofuel projects smoothly into society, the energy transition would be one step closer to phasing out fossil fuels completely. Both of these challenges demand due diligence and thought because to have one without the other does not create a sustainable solution for the world.