Thesis Project Portfolio

Production of a Butanol Based Biofuel from Second Generation Feedstock

(Technical Report)

What Does it Mean to be Green: Analysis of Sustainable Product Production

(STS Research Paper)

An Undergraduate Thesis
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Sociotechnical Synthesis

The electrification and decarbonization effort has reached a fever pitch in recent years. The drive to reduce greenhouse emissions and implement sustainable technologies has gained widespread support and seen several legislative victories. One area of sustainability that has received widespread investment are biofuels. Biofuels are used in the same systems as traditional gasoline and diesel, but they are created through biological mechanisms such as fermentation instead of crude oil distillation. By creating fuel this way, no additional carbon emissions are dispersed to the atmosphere, effectively halting a large portion of transportation related carbon emissions. One promising biofuel is Butanol. Butanol has favorable energy density compared to other commercial biofuels and can be used as a gasoline additive or replacement. While the concept of green technology like this seems great in theory, in practice some significant humanitarian challenges have arisen. Many of these challenges are evident in the extraction of metals like lithium and cobalt, while these materials are not used in the production of biofuels, they are used to produce batteries for electric vehicles, laptops, phones, and more. Furthermore, the definition of a "green" technology is often vague, nebulous, and often developed to misinform consumers. I believe that In order to "close the loop" on sustainable technologies considerable effort needs to be given to harmonize marketing around sustainable technologies and humanize the processes through which we create them.

The technical portion of this thesis centered around the creation of a theoretical biobutanol production plant. This facility is designed to produce 57 million kilograms of butanol every year, which is similar to a typical ethanol production facility. Ethanol is currently the most widely produced biofuel, but switching to butanol offers significant increases in product energy density, lower volatility, and an increased compatibility with existing combustion engines. This plant uses "ABE" fermentation to generate acetone, butanol, and ethanol products. This process entails the use *of Clostridium acetobutylicum* bacteria to convert glucose derived from corn stover into usable biofuels. Notably, the feedstock for this plant is second generation corn stover which is comprised of the inedible parts of a cornstalk. This is significant because virtually all current biofuel plants use first generation feedstocks, which are edible foods now being used to make fuel instead of feeding people. Furthermore, our plant uses a pervaporation process to purify the butanol from the other components that the plant creates. This process is more energy efficient than the traditional distillation techniques used historically. The plant also generates a significant amount of calcium hydrogen phosphate enriched animal feed that serves as the primary revenue driver for the plant.

In the sociotechnical portion of this thesis, I examine the dishonestly around "green" products by looking at the resource extraction industry through the Actor Network Theory framework. The resource extraction industry is notorious for abusing labor and destroying communities, especially in low-income countries. First, a review of the typical development of these industries is conducted to highlight how the subjugative relationship between resource extraction companies and local communities' forms. Next, an analysis is conducted of a potent example of these relationships: the current environment in the Democratic Republic of the Congo, specifically as it related to cobalt extraction. This situation highlights the dire need for

some form of regulatory or humanitarian intervention in the industry, as the detrimental and irreversible impacts the industry is having on the Congolese people grow worse by the day. I continue by proposing ideas to attempt to mitigate the damage being done, and to encourage the use of regulations and involvement of nonprofit groups to mediate. Lastly, I enumerate how truly sustainable extraction practices could be marketed and supported by corporations and consumers to increase equity and transparency.

The purpose of considering a seeming unrelated industry- resource extraction- in a project centered about biofuel is in the hope that the world could learn from its mistakes. I think the global consensus is that society needs to move away from fossil fuels and towards a society that does not actively destroy its home planet. However, in the current climate, it is the most impoverished among us who are bearing the ugly burdens of the rest of society. This is not sustainable in the long term, and the sooner we are able to remedy current injustices, the sooner we will be able to develop a framework for creating ethical and equitable processes that deliver holistically sustainable technologies across a wide range of applications.

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