Applicant: Colorado State University, Fort Collins, CO

Project Title: Electro-Enhanced Conversion of Wet Waste to Products Beyond Methane

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Project Objectives: The overall goal of this project is to valorize wet organic waste by using cheap, renewable electrons to drive targeted pathways in anaerobic digestion (AD). By upgrading carbon metabolism through electrical stimulation, we will reduce CO_2 emissions and produce higher value fuel intermediates/blendstocks. AD will be enhanced for increased feedstock conversion and reduced methanogenesis, leading to increased production of volatile fatty acids and CO_2. CO_2 will be returned to the process as C2 compounds via microbial electrosynthesis. Two approaches will be used to produce higher value products: electro-elongation to caproic acid in a novel electro-film bioreactor, and bioconversion by engineered bacteria to higher alcohols. We expect a 25% or higher increase in feedstock conversion and a 60% or higher reduction in methane production, with the resultant available carbon being redirected to carboxylates; initially as VFAs but subsequently upcycled to medium-chain fatty acids using microbial electrosynthesis. Demonstration of the developed technology will occur in the GasCube, a pilot-scale 2-stage anaerobic digester currently operating at SDSM&T. As quantitative metrics of the enhanced AD process, the levelized cost of energy production will be improved by at least 25% over the baseline value of \$0.12 $kW \cdot h^{-1}$, and the net levelized cost of disposal will be improved by at least 25% over the baseline value of \$80/ton.

Potential Project Impact: By combining enhanced wet organic waste reduction with cheap renewable electrons to produce higher-value fuels and chemicals, the proposed system is a unique and innovative solution to multiple social and environmental issues. The electro-film bioreactor represents a unique merging of disparate technologies to increase gaseous feedstock uptake, reduce product inhibition, and utilize electrons efficiently for increased production rate and titer.

The U.S. produces over 115 MM dry tons of organic waste every year, most of which is landfilled or land applied. Of the fraction that is anaerobically digested, the majority of the methane is flared and the CO_2 remains uncaptured. Of the >16,000 AD units in the US, only ~1240 use the methane and this number is dropping due to cheap methane. There are an additional 11,000+ AD opportunities in the US, but the economics are poor. Developing higher-value products for AD will provide economic opportunities and additional jobs for thousands of communities. The project will also provide technical and research opportunities to dozens of students and postdoctoral researchers, and will communicate the project objectives to younger students and the public through an innovative outreach program. This will educate the next generation of researchers in an emerging field of waste valorization.

This proposal leverages prior DOE funding to NREL and CSU in microbial electrosynthesis, wet waste conversion, AD product recovery and methane reduction, and lignocellulosic feedstock conversion. The proposed work is outside the scope of those projects.