# Composting Coupled with Gaseous $CO_2$ Capture

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## Introduction

Gigaton-scale carbon dioxide removal is necessary to meet our climate targets. The carbon removal industry lacks technologies that are low-cost and scalable with high durability storage. For the first time, we demonstrated a low-cost carbon removal technology that captures and sequesters $CO_2$ from the industrial composting of biomass waste materials. Composting utilizes naturally occurring microorganisms to convert part of the carbon stored in biomass to $CO_2$ via aerobic respiration.

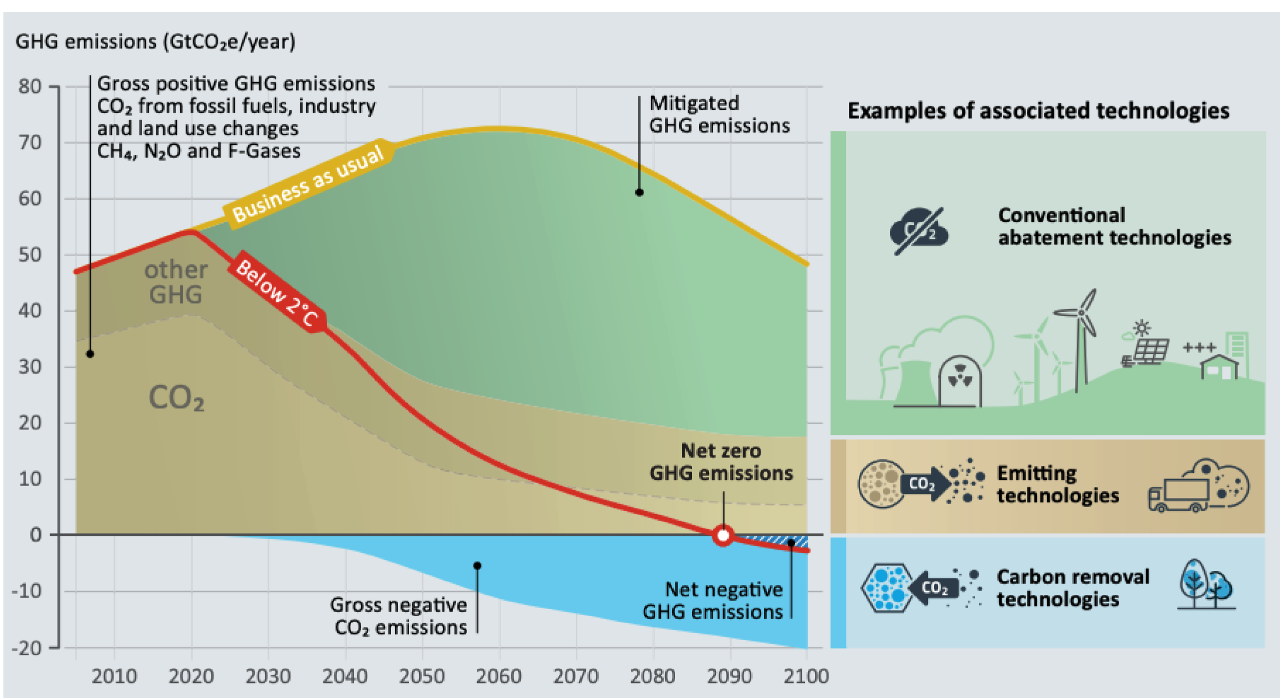


**Figure 1.** IPCC plot showing the important role negative GHG emissions, or carbon dioxide removal, is expected to play in limiting global warming to < 2 °C

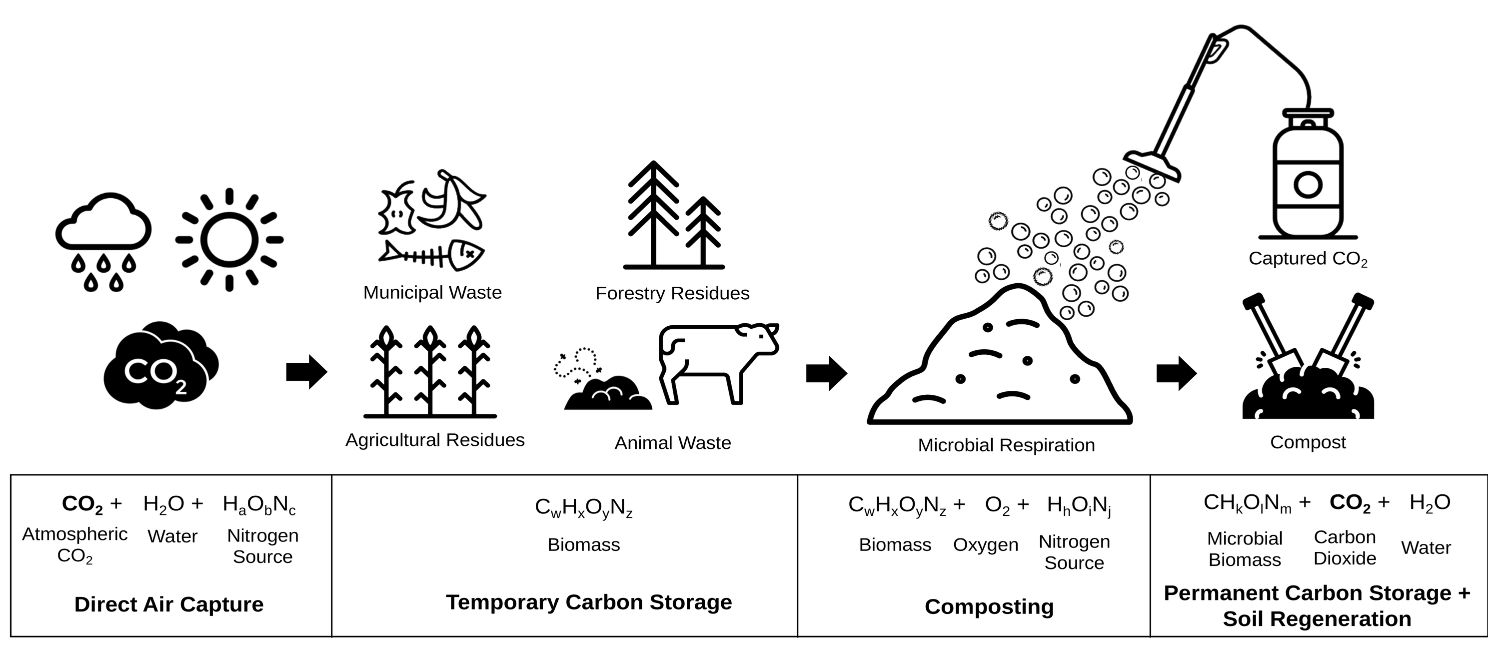


**Figure 2.** Schematic of the flipped composting process for atmospheric carbon removal

## Objectives

- Achieve high purity $CO_2$ from composting with air and oxy-fuel
- Achieve > 40% conversion of food waste-carbon to $CO_2$ in less than 15 days
- Achieve a levelized cost of carbon removal < \$100 per $tCO_2$

## Methods

- Food waste from NCSU's compost facility was used as compost feedstock
- Active compost from NCSU's compost facility was used as an inoculum for the reaction
- Compost was mixed and added to reactors equipped with $CO_2$, $O_2$, RH, temperature, and pressure sensors
- Gases were extracted and added to generate both compost and a high purity $CO_2$ product
- Techno-economic analysis performed using the capital recovery factor to calculate levelized cost of $CO_2$ removal, including LCA for emissions

## Results

The composting industry is ripe for innovation. In general, traditional composting systems are not highly engineered. The incorporation of carbon removal into composting offers several economic and technical advantages.

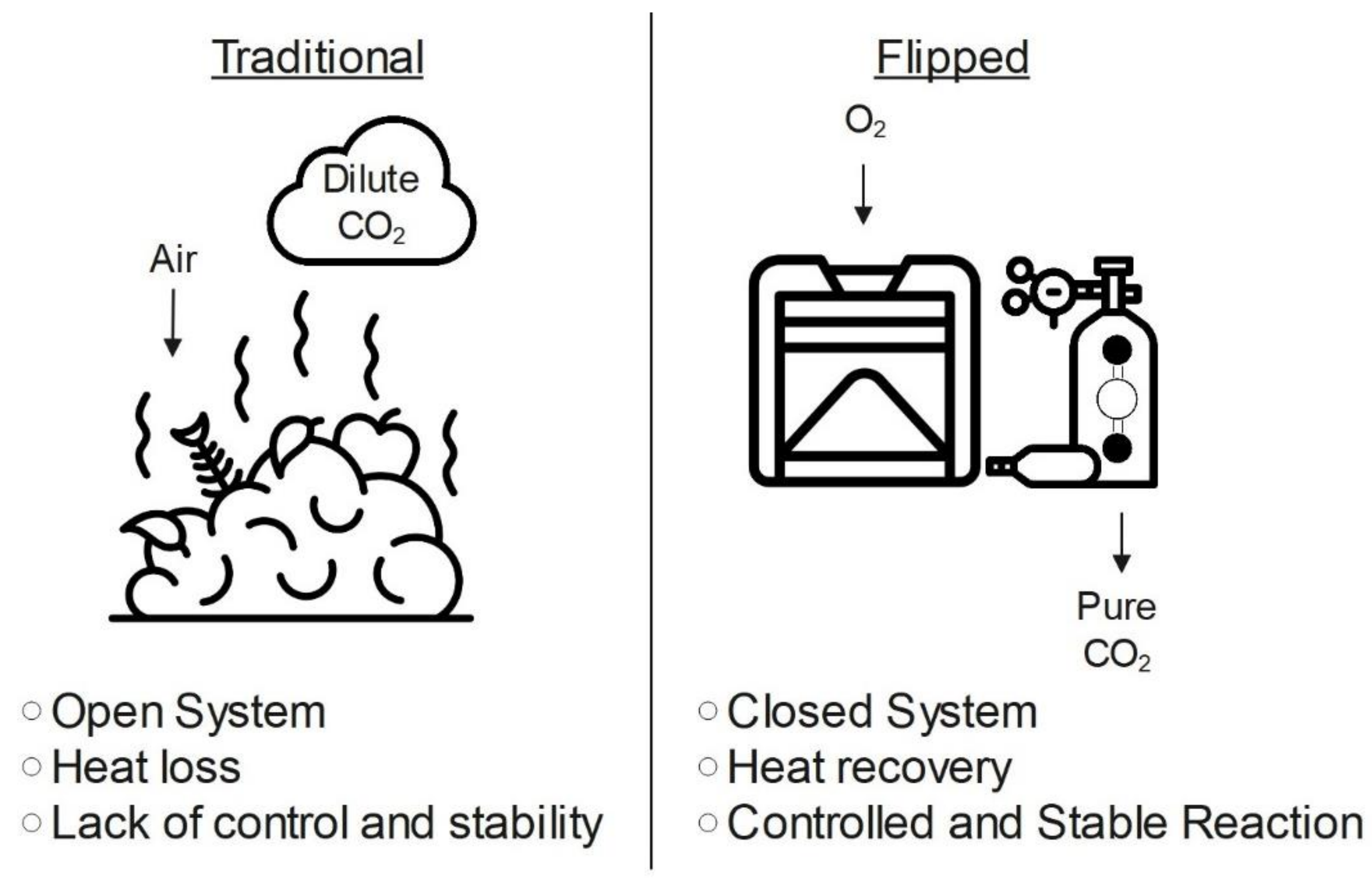


**Figure 3.** Comparison of traditional and flipped composting technologies

Composting of food waste in closed reactors with gas control measures enables the production of high purity biogenic $CO_2$

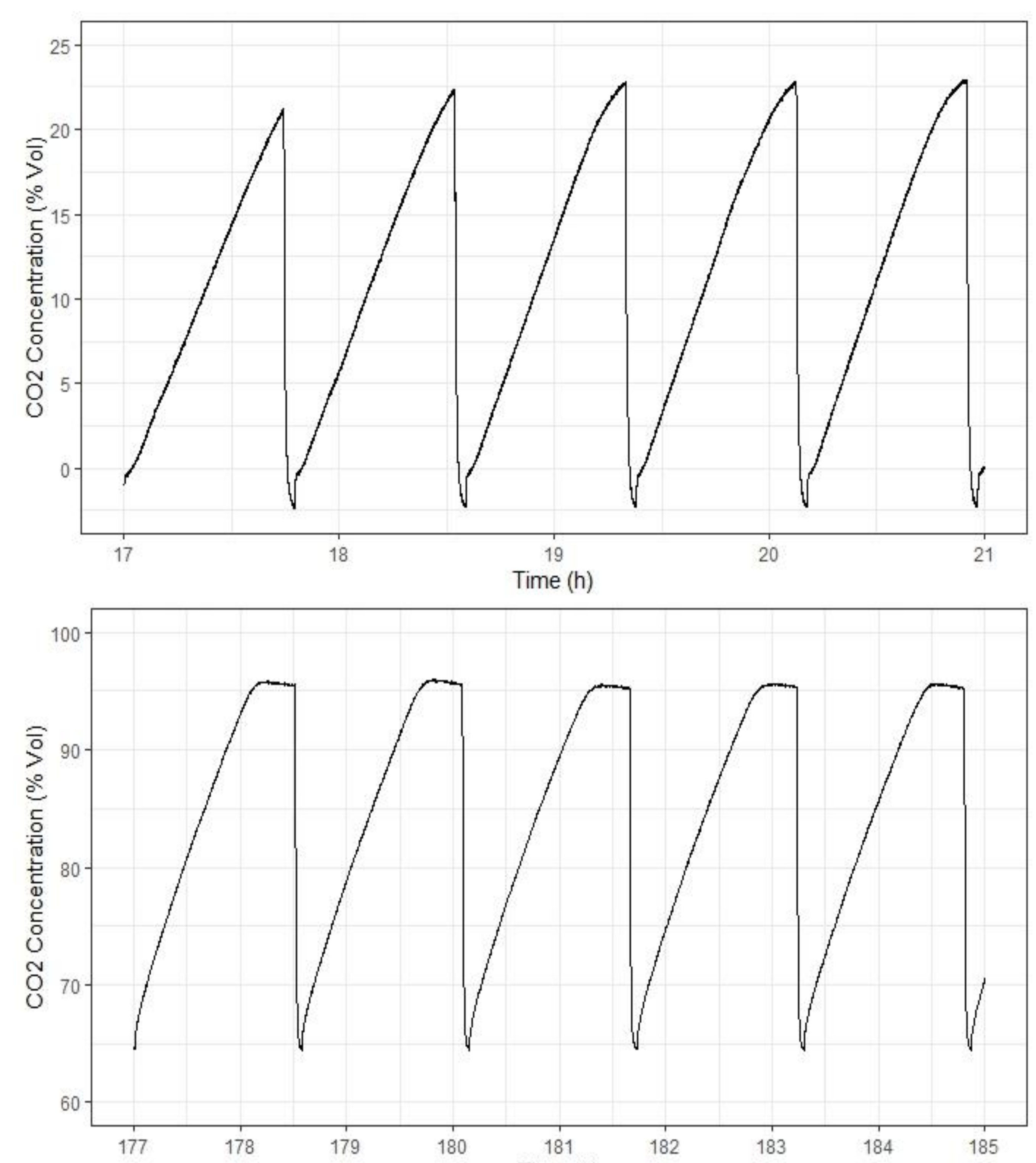


**Figure 4:** Concentration of carbon dioxide during five cycles of air-fuel flipped composting (top) and oxy-fuel flipped composting (bottom)

## Results

A sensitivity analysis identified critical techno-economic parameters, including capacity, tipping fee, and capital recovery factor. Baseline conditions: capital recovery factor (16%), biomass transport distance (30 mi, 48km), capacity (57 dry tonne biomass/day), biomass feedstock tipping fee (\$50/wet tonne), and compost selling price (\$35/wet tonne).

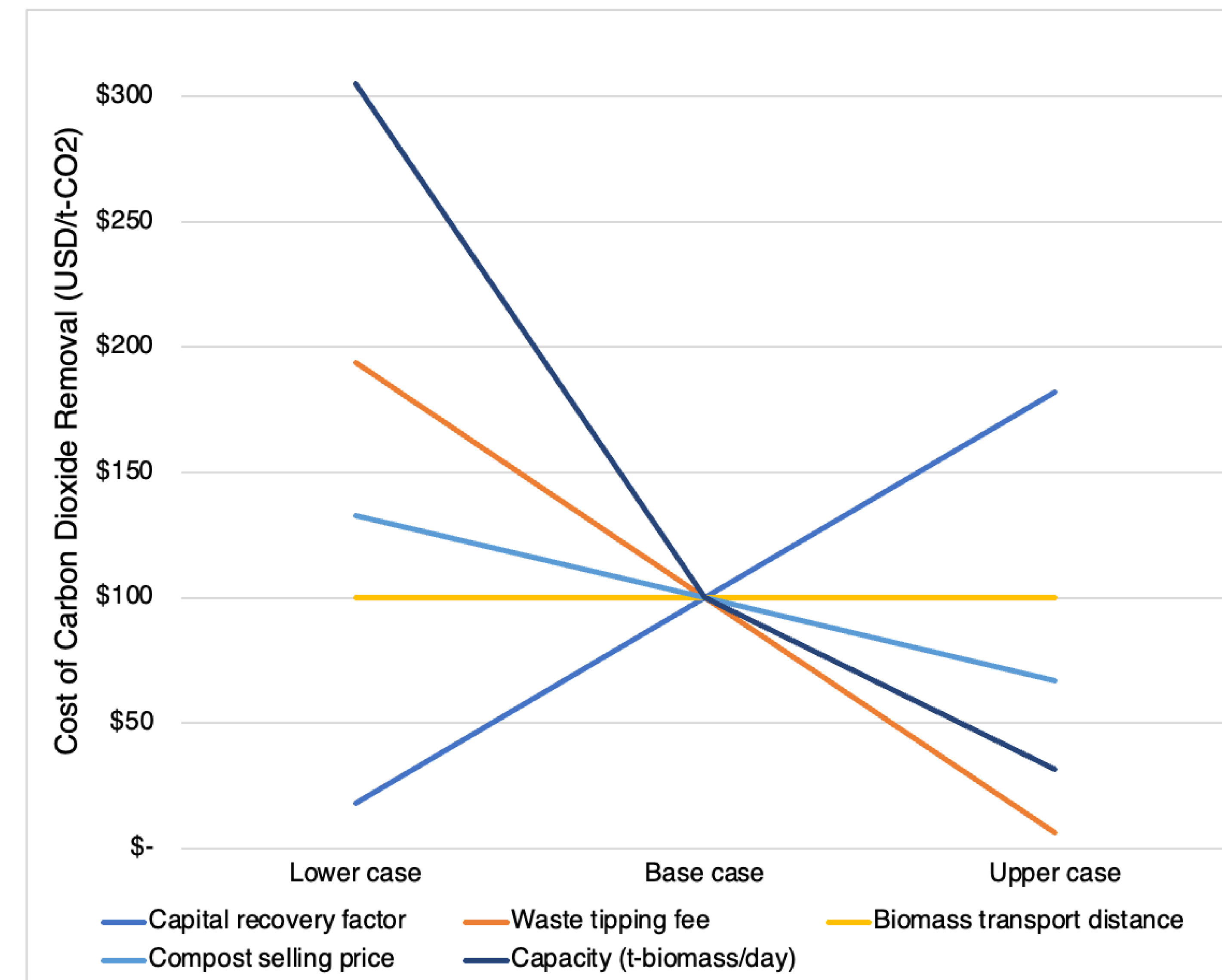


**Figure 5.** Sensitivity plot showing cost of $CO_2$ removal with +/- 50% fluctuation in certain technical and economic parameters

## Conclusions

For the first time, we demonstrated the potential of atmospheric carbon dioxide removal via composting of food waste with $CO_2$ capture. Relatively small scale operation (57 dry ton biomass/day) appears to be economically viable with modular pressure swing adsorption units for $O_2$ generation. $CO_2$ removal costs approaching \$0 are possible with low capital recovery factor, high biomass capacity, and/or high biomass feedstock tipping fee.

## Next Steps

We have filed two provisional patents and are moving towards commercialization. A startup company, Flip Biosystems, intends on licensing the technology from NC State University. High throughput optimization experiments are being completed on the bench scale. A pilot scale reactor is being constructed for demonstration under more realistic conditions. Feedstocks other than food waste will be assessed.

## Acknowledgements

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