Abstract

A global call to action, the Paris Agreement outlines a common goal to limit the rise of average global temperature by the year 2100 to within 2ºC of pre-industrial levels. Emerging from this goal and the inevitability of irreversible damage to the environment is a dire need for negative emissions technologies, which are projected to mitigate human emissions enough to meet this goal. Bio-energy with carbon capture and storage, or BECCS, is a process that engages the decarbonizing effects of biomass production. Biomass is grown and then combusted in a biomass-fired power plant to generate electricity, and the carbon dioxide from the power plant exhaust is separated and diverted underground.

This thesis outlines an alternative model for BECCS that employs bio-waste as the primary feedstock for energy production, eliminating unnecessary and inefficient uses of water, land, and energy. Biomass is pyrolyzed to enhance the carbon density of the fuel, making transportation from source to power plant more efficient. The resultant biochar undergoes CO_2 gasification to produce synthesis gas, a viable feedstock for a solid oxide fuel cell, which produces power and a CO_2-rich stream that requires far less intervention before geologic storage. This new model offers a more reliable road to carbon negative energy by mitigating carbon positive elements of a traditional BECCS process.

This thesis focuses primarily on pyrolysis of biomass and gasification of biochar. Five bio-waste feedstocks were analyzed: walnut shell, coconut shell, pumpkin seed shell, pistachio shell, and corn cob. Opportunities for energy savings were identified when lowering pyrolysis temperature did not significantly affect biochar gasification. To address inevitable variability in bio-waste feedstocks, relationships between biomass composition and reactivity were sought, and the most promising result was a correlation between rate of conversion and biochar ash content.