Title: Economic and Environmental Analysis of Bioenergy with Carbon Capture and Sequestration (BECCS) Systems

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Project Goals: This project aims to examine the impact of carbon sequestration credits, biorefinery capacity, and energetic self-sufficiency on the cost optimal conversion technology for a biorefinery with carbon capture, and how this is expected to change into the future. Performance metrics include cost per gallon gasoline equivalent and the greenhouse gas balance of the biorefinery and supply chain system.

Abstract Text: Bioenergy with carbon capture and sequestration (BECCS) involves simultaneous fuel production with permanent carbon dioxide removal (CDR) to achieve net-negative emissions. A variety of fuels can be produced by a range of biological and thermochemical conversion technologies. Conventional liquid fuels can be produced via fermentation, pyrolysis, or gasification. Additionally, hydrogen can be produced via gasification and the water-gas-shift reaction, or electricity can be produced by via either direct combustion or integrated gasification and combustion. Each conversion technology to fuel combination results in point sources of CO_2 emissions with different flow rates and purity from which CO_2 could be captured.

Previous studies are typically limited to a single conversion technology and capture source, or a small subset of the potential options, at consider a fixed biorefinery capacity. We use a mixed-integer nonlinear programming (MINLP) model of a lignocellulosic biorefinery and supply chain system that includes biorefineries utilizing fermentation, pyrolysis, gasification, or combustion, capture from any point source, and options to purchase hydrogen or electricity to increase fuel yield or capture rates as appropriate. We examine the impact of input parameters such as carbon sequestration credit, biorefinery capacity and energetic self-sufficiency on the economic and environmental performance of BECCS systems. In addition to determining the expected greenhouse gas (GHG) mitigation based on the current production mix, we compare the expected GHG mitigation into the future as the energy production mix changes.

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