Agent-based Modeling for the Multi-objective Optimization of Energy Production Pathways

Jason Quinn (PI), Steve Simske, Thomas Bradley, John Field-Colorado State University
Jordan Kern-North Carolina State University, Colin Beal-B&D LLC

Project Description: The proposed work will develop a toolset that is capable of identifying promising combinations of production pathways and performance targets for bio-energy and co-product systems. This is a new paradigm for bioenergy modeling. The work will leverage agent-based modeling for the optimization of biofuel production pathways with geo-spatial resolution and multi-parameter optimization that includes cost, energy, water, and emissions criteria.
Objectives of the Project: The work is divided in to four interconnected objectives: 1) development of modular engineering process models, 2) development of concurrent sustainability models, 3) optimization and evaluation of bioenergy configurations, and 4) External review. The four objectives above integrate to facilitate the evaluation of the US bioenergy sector. Foundational modeling work will build upon existing single-product models by adding a network multi-objective optimization economic and environmental model coupled with agent based modeling.
Project Methods: Budget Period 1: The initial efforts of the project focuses on the development of foundational sustainability models. The work includes integrating existing sub-process models with the development of new sub-process models to accurately capture the performance of various demonstrated and innovative bioenergy production pathways. The engineering process models will be constructed in a modular fashion to support the agent-based and multi-objective optimization work in BP2. The developed modular engineering process models will serve as the foundation for sustainability assessment through techno-economics and life cycle modeling. We will identify the energy, mass, labor, and financial inputs required for each production pathway, such that synergies and optimizations can be formulated in BP2.
Budget Period 2: Work will focus on integration and optimization techniques based on the foundational work developed in the BP1. The various system configurations will be evaluated through agent-based modeling, multi-objective optimization, and carbon accounting through coupling economic and environmental assessment. In addition, resources are allocated to the development of additional sub-process unit operations to capture new and innovative technologies, such as favorable configurations of bioenergy with carbon capture and storage (BECCS). The results from the project will be transformed into an open-source tool-set that will support the evaluation of various combinations of technologies – such that a use can evaluate tradeoffs of bioenergy production pathways.
Project Impact: The work proposed here represents a paradigm shift in sustainability as it includes concurrent economic, environmental, and resource assessment of the entire bioeconomy coupled with multi-function optimization and agent-based modeling, while including next generation integrated environmental and economic methodologies based on carbon accounting. The results from this work will highlight technology pathway combinations that meet water, energy, GHGs, and pollutant performance targets. The work focuses on a transparent tool-set that can support strategic research initiatives by the DOE.
Project Team: The team consists of personnel from CSU, NCSU, and B&D and represent leading experts in the sustainability field covering a broad range of bio-based feedstocks and conversion pathways. Project coordination will be based at the PowerHouse Energy campus at Colorado State University.