BRC Science Highlight
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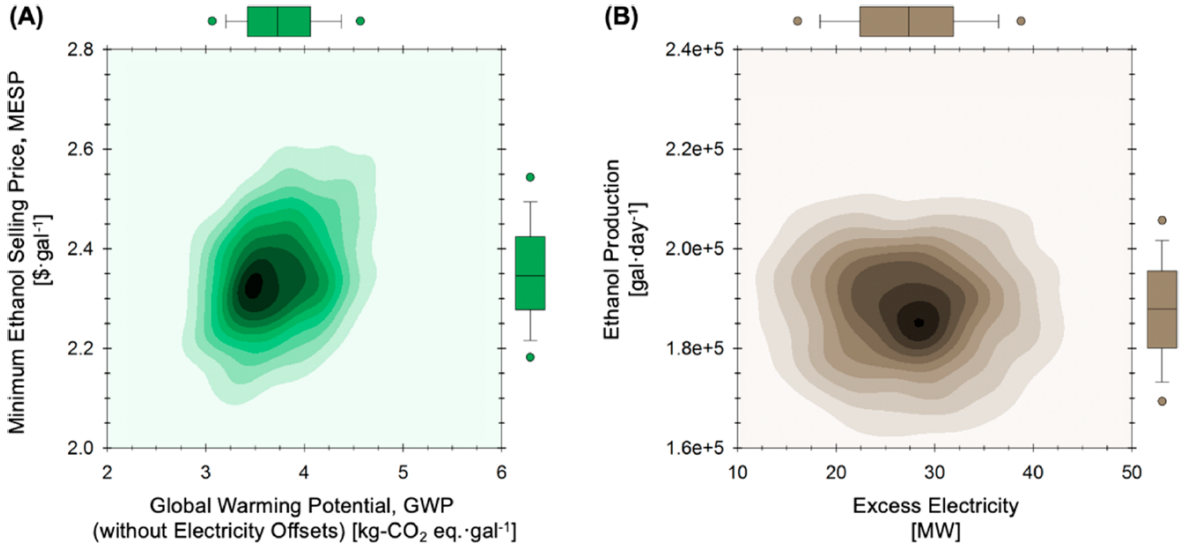
BioSTEAM-LCA: An Integrated Modeling Framework for Agile Life Cycle Assessment of Biorefineries under Uncertainty

Objective

Biorefineries will play a key role in the sustainable bioeconomy, but accurate projections of their environmental impacts are hampered by life cycle assessment (LCA) methodologies that are disconnected from biorefinery design, simulation, and techno-economic analysis (TEA). Here, researchers address this shortcoming with a new agile LCA framework, BioSTEAM-LCA[1], which integrates with the BioSTEAM[2] platform to characterize biorefinery environmental impacts across the design, technology performance, and contextual landscape.

Approach

- Developed an agile, open-source BioSTEAM-LCA framework in Python with flexibility to conduct rapid and robust TEA-LCA analyses of user-defined candidate products and processes.
- Demonstrated BioSTEAM-LCA utility by quantifying life cycle environmental impacts and minimum fuel selling price of a sugarcane ethanol biorefinery under uncertainty.



Gate-to-gate LCA and TEA results for ethanol production from sugarcane. Shading represents the density of results from 1000 Monte Carlo simulation runs. Box-and-whisker plots represent the same data as kernel density maps.

Results

- Used BioSTEAM-LCA to evaluate decision space of a sugarcane ethanol biorefinery. The design, simulation, TEA, and LCA of 1,000 scenarios took 5 minutes, 48 seconds on a personal computer.
- BioSTEAM-LCA can be used to elucidate the relative importance of individual factors using global sensitivity analysis, which can then be used to set technology development targets to achieve specific reductions in environmental impacts and costs.

Significance

BioSTEAM-LCA and BioSTEAM facilitate quantitative sustainable design of biorefineries, enabling research and development to be prioritized to achieve biofuels and bioproducts that are both environmentally sustainable and financially viable. BioSTEAM and BioSTEAM-LCA can serve as a foundation to generate new process models to evaluate emerging technologies, bioproducts, and biofuels.

[1] *Shi, et al. 2020. "BioSTEAM-LCA: An Integrated Modeling Framework for Agile Life Cycle Assessment of Biorefineries under Uncertainty." ACS Sustainable Chemistry and Engineering. DOI: 10.1021/acssuschemeng.0c05998.*

[2] *Cortes-Peña, et al. 2020. "BioSTEAM: A Fast and Flexible Platform for the Design, Simulation, and Techno-Economic Analysis of Biorefineries under Uncertainty." ACS Sustainable Chemistry and Engineering. DOI: 10.1021/acssuschemeng.9b07040.*

CABBI CENTER FOR ADVANCED BIOENERGY AND BIOPRODUCTS INNOVATION
U.S. DEPARTMENT OF ENERGY