Life cycle analysis and optimization for sustainable synthesis of biofuels and bioproducts pathways

Fengqi You
Northwestern University

Abstract:
Biomass-derived chemical products may offer reduced environmental impacts compared to their fossil-derived counterparts and could improve profit margins at biorefineries when coproduced with higher-volume, lower-profit margin biofuels. This presentation will begin with our recent life cycle analysis (LCA) study on assessing the life cycle energy and environmental impacts of 8 bioproducts selected on the basis of technology readiness and market potential. We developed high-fidelity process simulations to obtain energy and material flows in the production of each bioproduct and examined sensitivity of these flows to process design assumptions. Conversion process data were combined with upstream and downstream life cycle environmental impact parameters to determine the cradle-to-grave environmental impacts of each bioproduct. Data and results of this study have now been included in Argonne GREET model.

Building on the data and approach of the LCA study, we further develop a superstructure-based computational framework for sustainable design and synthesis of algal biorefineries that produce fuels and value-added chemicals. This framework simultaneous models detailed mass and energy flows within the biorefinery, and organically integrates with technoeconomic analysis and LCA. It systematically evaluates various technology alternatives and determines the optimal product portfolio for making different biofuels and bioproducts from a given algal feed.

At the end of the presentation, we will discuss a comprehensive biofuels and bioproducts conversion network, with 200 conversion technologies and 142 compounds (feedstocks, intermediates, and final products). This bioconversion network represents various pathways for making 4 types of biofuels and 9 bioproducts from 11 terrestrial and aquatic biomass feedstocks. We develop a network-based life cycle optimization framework to identify the most cost-effective and environmentally sustainable production pathways for a given feed or a specific demand. We will discuss general modeling frameworks, efficient solution algorithms, and case studies illustrate the applications of these frameworks.