NREL | NATIONAL BIOENERGY CENTER

NREL'S CAPABILITIES IN **BIOREFINERY ANALYSIS**

NREL remains at the forefront of expertise in conducting process, techno-economic, and life cycle analyses to connect research with future commercial process integration, a critical step in the scale-up of biomass conversion technologies.

Techno-Economic Analysis and Life Cycle Assessment

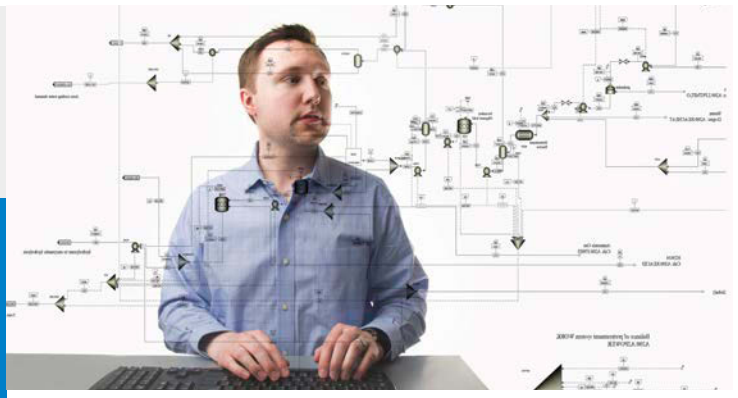
Techno-economic analyses (TEAs) can be useful in determining the potential for near-, mid-, and long-term viability of emerging technologies. The results of a TEA are also instrumental in directing research toward areas where improvements will result in the greatest cost reductions. Similarly, life cycle assessment (LCA) is important for determining the environmental benefits and burdens of a process technology that may be utilized by federal and state energy agencies to assess the potential to support policies such as the U.S. Energy Independence and Security Act's Renewable Fuel Standard and California's Low Carbon Fuel Standard. Analysis studies may also include broader market perspectives as warranted. Key TEA and LCA activities include:

- Detailed process simulations with mass and energy balances
- Sensitivity studies to highlight the impact of major cost or sustainability drivers
- Setting research/cost targets and benchmarking progress against current baselines (specific to TEA)
- Quantifying current or potential future environmental sustainability metrics such as greenhouse gas emissions, fossil fuel requirements, or water use (specific to LCA).

Technology Areas

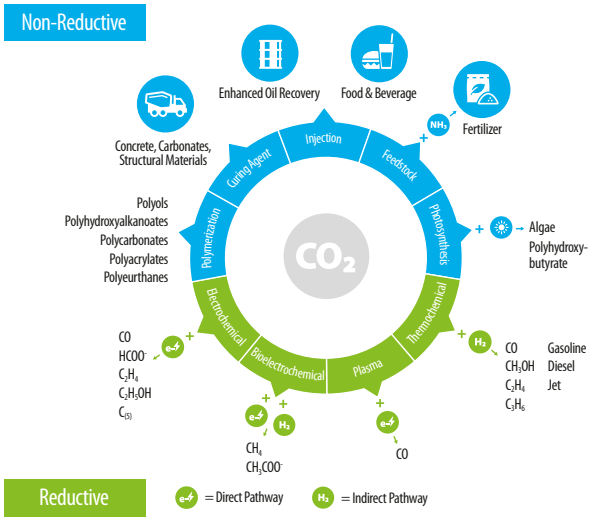
Lignocellulosic Biorefineries: NREL maintains core competencies in TEA/LCA modeling across a suite of lignocellulosic biorefinery technology pathways. This includes biochemical conversion processes (via deconstruction and upgrading of carbohydrates and lignin) as well as thermochemical conversion processes (via gasification and catalytic fast pyrolysis) for the production of fuels and value-added coproducts.

Top photo by Dennis Schroeder, NREL 30266



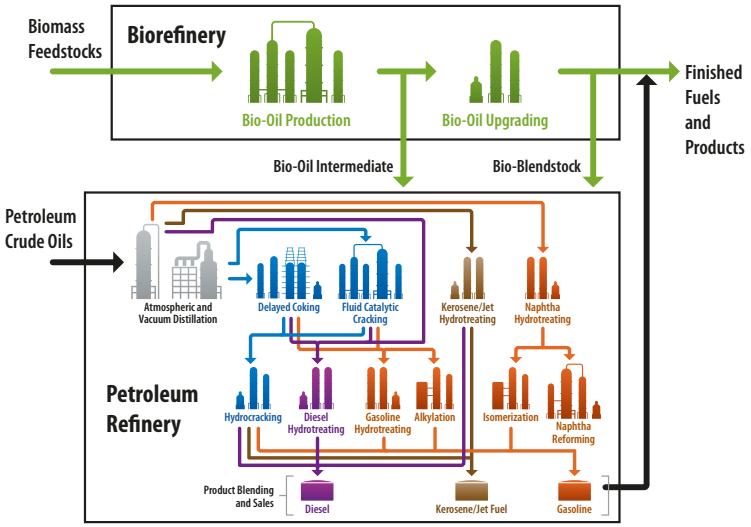
Algae: NREL remains at the forefront of algae TEA modeling, focused both on biomass cultivation (via open pond and photobioreactor farm models) as well as conversion (via algal biomass fractionation and conversion of individual constituents) for production of fuels and value-added products.

CO_2 Utilization: NREL is working to evaluate the potential for cost reduction and efficiency improvements under emerging "electrons-to-molecules" concepts, to (1) understand the fundamental technical and economic feasibility of utilizing electricity for CO_2 conversion strategies, (2) assess integration of these technologies with biomass conversion pathways, and (3) facilitate the evolution of these emerging technologies through leveraging TEA to identify key barriers and cost drivers.



Waste-to-Energy: NREL performs TEA for converting waste feedstocks to power, fuels, and bioproducts to understand opportunities across different waste conversion pathways, as well as to support novel research efforts being pursued in this space.

Aviation and Marine Fuels: To inform strategic directions expanding beyond motor vehicle fuel pathways, NREL has been developing a suite of economic evaluation scenarios that consider the near-term costs, research and development (R&D) needs, scale-up potential, and refinery blending opportunities of biojet and marine fuel pathways.



Refinery Modeling and Analysis: NREL utilizes optimizable refinery models to quantify opportunities for cost reduction and improved environmental performance of biofuel and bioproduct pathways through integration with existing refining infrastructure. These models allow for valorizing bio-derived products based on quality metrics, properties, and yields, as may be valued by a refiner through coproduction with petroleum products.

Circular Economy: NREL is developing TEA methodologies to evaluate emerging processes to support a circular economy. For example, researchers are exploring plastics deconstruction and upcycling technologies that address economic and environmental questions around "second life" of recycled materials, with TEA leveraged to guide novel R&D efforts.

How NREL Can Help

Allow NREL's team of analysis engineers to provide in-depth modeling and results based on your customized processes while maintaining the strictest confidentiality. The team maintains world-renowned expertise with widely recognized TEA reports spanning over two decades, with new capabilities expanding across a range of technologies. This credibility has led to numerous successful wins on joint funding opportunity announcements and other collaborations.

Highlighted Publications

Davis, R., et al. *Process Design and Economics for the Conversion of Lignocellulosic Biomass to Hydrocarbon Fuels and Coproducts: 2018 Biochemical Design Case Update*. NREL/TP-5100-71949.

Davis, R., et al. *2017 Algae Harmonization Study: Evaluating the Potential for Future Algal Biofuel Costs, Sustainability, and Resource Assessment from Harmonized Modeling*. NREL/TP-5100-70715; ANL-18/12; PNNL-27547.

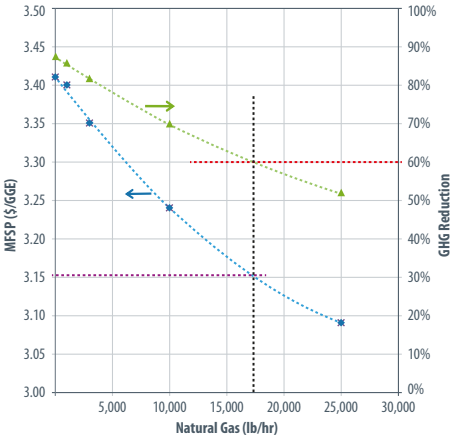
Dutta, A., et al. *Process Design and Economics for the Conversion of Lignocellulosic Biomass to Hydrocarbon Fuels: Thermochemical Research Pathways with In Situ and Ex Situ Upgrading of Fast Pyrolysis Vapors*. NREL/TP-5100-62455; PNNL-23823.

Project Successes

Researchers at NREL use process and sustainability analyses to understand the economic, technical, and environmental impacts of many technologies. These analyses reveal the economic feasibility and environmental benefits of such technologies and are useful for scientists and policymakers in both the public and private sectors. Over the years, NREL's biorefinery analysis team has collaborated with many companies, including ExxonMobil, Chevron, Petrobras, Ecopetrol, ConocoPhillips, and Honda, among others.

Examples of industry collaborations include:

- NREL performed TEA as part of an international collaborative effort with Petrobras, Ensyn, and Fibria that successfully demonstrated co-processing of pyrolysis oil in conventional refinery operations to produce biomass-derived fuels, including a diesel fuel blendstock that was registered and approved by the U.S. Environmental Protection Agency.
- Chevron and NREL collaborated to develop techniques to improve the production of liquid transportation fuels using microalgae. Researchers identified and developed promising microalgal strains. The collaboration relied heavily on NREL's TEA modeling to benchmark process economics and inform R&D progress within the effort.
- NREL has recently partnered with major industrial firms to evaluate opportunities for solving waste plastics issues, including polymer recycling technologies that could leverage NREL conversion capabilities. Under those partnerships, TEA and LCA modeling were instrumental in weighing various pathway options.



TEA-LCA tradeoff analysis for the use of supplemental natural gas in a biorefinery process. From NREL/TP-5100-62402.

Cellulosic biofuel life cycle GHG threshold (60% reduction from 2005 baseline)

Maximum natural gas input at 60% life cycle GHG reduction threshold

MFSP at 60% life cycle GHG reduction threshold

Find Out More

For more information and collaboration opportunities, contact:
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www.nrel.gov/bioenergy/economic-sustainability-market-analysis.html

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