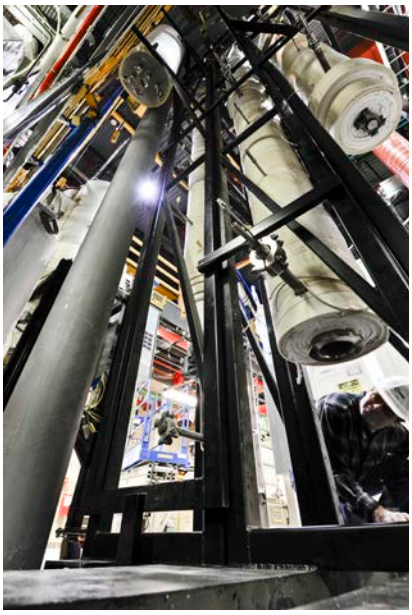
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

From Biomass to Biofuels – Leadership in R&D Implementation

About Our Research: NREL's research focuses on the replacement of petroleum with transportation fuels from biomass by delivering innovative, cost-effective biofuels solutions. Researchers explore biomass characterization, biochemical and thermochemical conversion processes, the chemicals and catalysts that optimize conversion, and the integration of those processes.

Recent Accomplishments:

- Integrated pilot-scale achievement of U.S. Department of Energy's (DOE) 2012 cellulosic ethanol cost targets demonstrating production of ethanol at a price competitive with gasoline.
- Developed solid base catalysts for lignin depolymerization at mild conditions and evaluated means for lignin fractionation from biomass using multiple pretreatment technologies.
- Converted deacetylated corn stover to ethanol at pilot-scale.
- Published technical memos for the priority DOE Bioenergy Technologies Office R&D technology pathways detailing the process designs for the production of hydrocarbon biofuels (in collaboration with Pacific Northwest National Laboratory).



The newly installed recirculating regenerating reactor system in the thermochemical pilot plant at NREL's Field Test Laboratory Building. *NREL 25486.*

- Discovered approaches for reducing coke formation by greater than 30% during vapor phase upgrading of pyrolysis vapors without increasing the amount of oxygen in the pyrolysis vapor.
- Developing a design report for techno-economic and sustainability assessment of biochemical conversion of cellulosic biomass to biofuels via biological conversion of sugars to hydrocarbons.
- Demonstrated the efficiency of bioconversion of algal biomass to both sugar-based ethanol fuel, lipid-based green diesel fuel, and protein-derived short-chain alcohol fuels.
- Metabolically engineered algae to produce ethylene for its conversion into transportation fuels, plastics, and chemicals.
- Developing a design report for updated techno-economic and sustainability assessment for thermochemical conversion.

In addition, all of NREL's patented biomass technologies are available for licensing, and NREL's world-class biomass user facilities are available to industry, university, and government researchers. NREL can provide trained staff to conduct or direct the work, or activities can be performed by staff from the participating organization.

Partner with NREL:

Please contact us if you would like to explore collaboration opportunities with NREL's Biomass Program.

Contact Rich Bolin, phone: 303-384-7716, e-mail: richard.bolin@nrel.gov. For online information about all the topics discussed above, please see:

www.nrel.gov/biomass/workingwithus.html

An NREL researcher scanning solid biomass samples for rapid near-infrared (NIR) compositional analysis based on chemometric models. *NREL 26487.*

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Biomass to Sugars and Sugars to Products

Fully Integrated Biomass to Fuel R&D Capabilities and Expertise via "Sugar" Intermediates. Examples include high-throughput (HTP), variety of bench (mililiters to liters) and pilot (100-1000 liters) reactors for pretreatment, saccharification, and fermentation, as well as fundamental scientific understanding, targeted biocatalyst and unit operation development, and optimization/integration of unit operations.

Implementation examples include cooperative development of individual pretreatment technology, enzyme, and strain in 2012, cellulosic ethanol demonstration with integration of pretreatment , enzymatic hydrolysis, and fermentation from bench to pilot. In addition, for more than a decade NREL has produced state-of-technology reports that provide a historic record of how incremental improvements to individual unit operations could be integrated to bring the selling price of cellulosic ethanol down to a level that can compete with gasoline.

Biomass to Oil, Oil to Products and Gasification

Fully Integrated Biomass to Fuel R&D Capabilities and Expertise via Syngas and Bio-oil Intermediates. Examples include HTP screening, variety of bench- (kilograms to grams) and pilot-scale (kilograms catalyst) equipment and capability; fundamental scientific understanding; and targeted unit operation development, optimization, and integration.

Implementation examples include cooperative development of technology for tar/methane reforming catalyst, mixed alcohol catalyst, catalyst regeneration/recycle for cellulosic ethanol demonstration from gasification, and integration of gasification with mixed alcohol unit operations (syngas generation, cleanup, and fuel synthesis) from bench to pilot scale. In addition, NREL produced state-of-technology reports that represent a historic record of how incremental improvements to individual unit operations could be integrated to bring the selling price of cellulosic ethanol down to a level that can compete with gasoline.

Techno-economic and Sustainability Analysis

Techno-economic analysis and life-cycle analysis models for a wide range of feedstocks, conversion technologies, and fuels including terrestrial and algal feedstocks, biochemical and thermochemical conversion, and fuels based on sugars, lipids, lignin, and proteins. Our analyses are recognized as well-informed and unbiased based on solid collaborations with academic and industrial leaders in the biofuels community.

Implementation examples include public, externally peer-reviewed design reports on cellulosic ethanol (biochemical and gasification) with detailed models used by DOE and industry, and numerous collaborative efforts on proposals and research and development agreements leveraging NREL techno-economic expertise.

Compositional Analysis

Method/instrument development for accurate/precise measurement of key chemical constituents in raw biomass as well as in sugar, syngas, pyrolysis vapor, bio-oil, and algal lipid intermediate streams and development of fast analytical techniques (for example, Near infrared) and chemometric models to predict chemical composition and feedstock reactivity on a wide range of feedstocks and intermediates.

Implementation examples include development of heat integration strategies to optimize where biomass should be dried (field vs. plant), and evaluation of impacts of natural feedstock variability, ensiling, and other feedstock logistics cost reduction strategies on conversion and total cost of ethanol production.

Algal Biomass to Fuels

Development of algal strains, conversion technologies, compositional analysis techniques, and techno-economic models.

Implementation examples include algal strain development for high lipid productivity, development of highly productive, stable cyanobacteria for ethylene production, development of biomass fractionation and conversion processes, development of critical compositional analysis methods, and collaboration with Pacific Northwest National Laboratory and Argonne National Laboratory to produce the harmonized model for cost, emissions, and resource potential for algal biofuels.

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National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
303-275-3000 • www.nrel.gov

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