Transforming Biomass to Bioenergy Feedstocks

Biomass offers great promise in the 21st century as one of the best sources of clean, renewable and sustainable energy for fuel, electricity and valuable bioproducts.

The DOE Biomass Program has shaped the vision of a national, commodity-scale feedstock supply system. Much progress has been made in developing and reaching this vision through optimizing biomass logistics—and defining commodity attributes compatible with existing commodity-scale, solids-handling infrastructure. Now, this commodity vision is expanding to include the development of next generation customized feedstocks that are also optimized for conversion performance. This vision enables commodity-scale, custom-formulated feedstocks to play a critical role in producing biofuels, biopower and other bioproducts.

The mission of the Idaho National Laboratory Bioenergy Program is to achieve the DOE vision by developing processes and technologies—through applied science and engineering—that focus on:

- Supplying high-quality raw biomass,
- Preprocessing raw biomass into advanced bioenergy feedstocks, and
- Delivering bioenergy feedstock commodities.

Supplying high-quality, raw biomass

The building blocks to supply high-quality raw biomass start with harvesting and collection practices, product storage and recommendations of best management practices.

Harvesting and collection systems

The goals of advanced biomass harvest and collection R&D are to: 1) reduce costs by optimizing biomass logistics through improved machinery efficiencies, 2) maximize raw biomass quality by minimizing soil contamination and controlling moisture effectively, and 3) promote sustainable management practices.

Storage systems

The goal of biomass storage R&D is to provide cost-effective solutions for preserving biomass quality and quantity. Advanced storage systems employ definable and measurable storage conditions that extend shelf life. Storage management based on shelf life ensures acceptable quality and enables the use of high-moisture harvesting technologies not otherwise feasible when using conventional biomass storage practices.

Recommending best management practices

Biomass harvest, collection, and storage R&D provide the basis for recommended practices to supply highest quality, on-spec biomass. Biomass supply systems must be versatile enough to allow suppliers to deviate from recommended practices in favor of alternative approaches that best suit their business.

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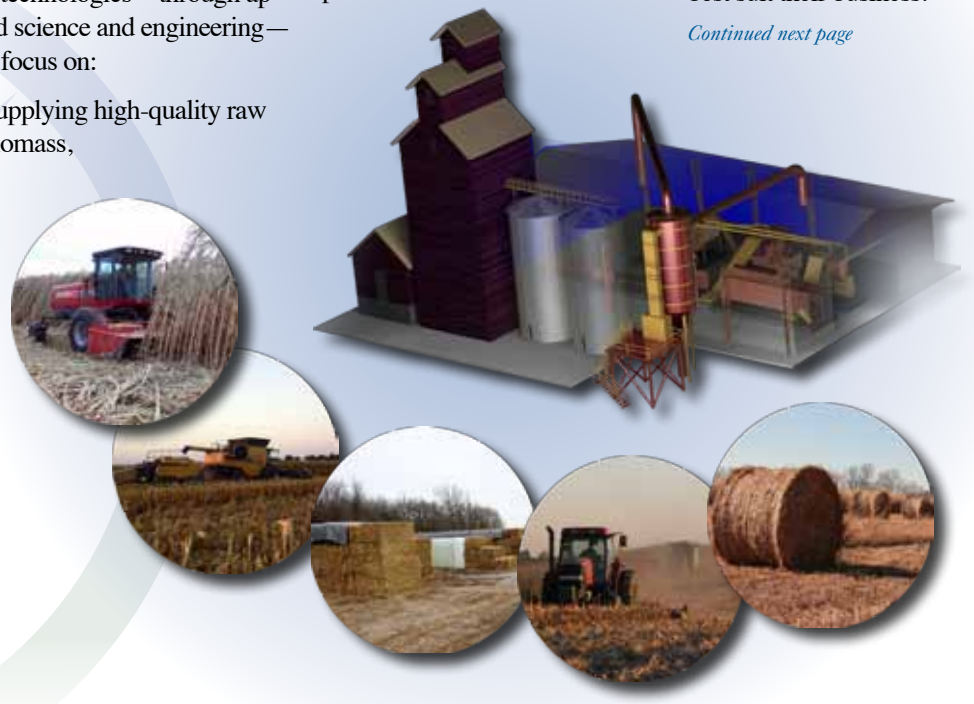

The Energy of Innovation

INL
Idaho National Laboratory

PREPROCESSING RAW BIOMASS INTO ADVANCED FEEDSTOCKS

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Progress made in supplying the highest quality, low-cost raw biomass has come a long way to enable today's biorefining industries—and now, biomass refiners and feedstock researchers are collaborating to develop next generation customized feedstocks that are also optimized for conversion performance.

Converting biomass to high-value feedstocks

Advanced feedstocks play an important role in economically and efficiently converting biomass into bioenergy products. Advanced feedstock recipes transform biomass from its diverse, raw forms into high-value, high-density, on-spec feedstocks that are optimized for bioenergy conversion performance.

This transformation involves intermediate preconversion steps that break down, clean up, stabilize, and make biomass more reactive to biochemical and thermochemical conversion. It also involves formulation steps that blend ingredients and densification steps that "set" the formulation for efficient handling and packaging.

Customized feedstocks are optimized for conversion performance, which offers the advantages of improved digestibility in biochemical conversion, reduced slagging and fouling in gasifiers and boilers, and more efficient handling. Custom formulation also enables limitless possibilities for development of new bioproducts and conversion processes.

Bioenergy R&D at Idaho National Laboratory

Transforming biomass from raw forms to customized feedstocks is the focus of the Bioenergy Program at Idaho National Laboratory. This research includes producing feedstock commodities, process affordability, customizing to specifications, and maintaining high value and quality.

Feedstock preprocessing research and development ranges from laboratory-scale applied science, bench-scale prototyping, and pilot-scale testing and demonstration as enabled by tools and systems developed by the Department of Energy's Office of Biomass Program.

With advanced biomass-to-feedstock preconversion tools and processes—entirely new bioenergy markets for tomorrow's biorefineries are possible.

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... FOR ADVANCED BIOFUELS, BIOENERGY AND BIOPRODUCTS

Upgrading through preprocessing technologies

The challenges of efficiently converting raw biomass into usable, affordable, customized bioenergy feedstdocks are many. The bioenergy industry will advance greatly through research on the three principal processes that characterize biomass feedstock engineering—preconversion, formulation and densification.

Preconversion – Preparing the Ingredients

Preconversion treatments are comprised of mechanical, thermal and chemical processes.

- Mechanical treatments tackle the challenge of reducing size, fractionating, and separating feedstocks for downstream processing. Size reduction is achieved through mechanical grinding and milling, which increases surface area and makes the biomass more reactive in subsequent processing steps. Fractionation breaks biomass into separate components that can be separated, concentrated, and later blended to form highly optimized, advanced feedstocks.
- Thermal and chemical treatments reduce moisture content, remove contaminants, and improve feedstock condition, processing, and stability. These treatments also produce molecular and structural changes that enhance biomass reactivity during conversion processes.

Formulation – Developing the Recipe

Formulation is the blending and mixing of biomass ingredients to develop customized feedstock recipes. Blended ingredients include treated or untreated biomass products, as well as chemical or biological additives that improve catalytic reactions and preserve a feedstock's best conversion attributes.

Densification – Setting the Recipe

Essential in feedstock formulation, densification uses temperature and pressure to create and "set" the mechanical and chemical bonds necessary to produce a high-density, stable, and consistent bioenergy commodity. Densification retains feedstock quality and enables efficient handling, transportation, and storage using existing equipment and handling systems.

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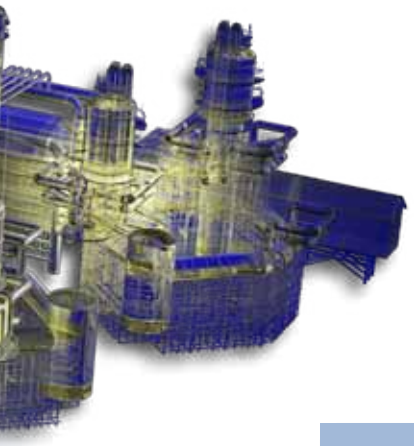
Using state-of-the-art research tools provided by DOE's Office of Biomass Program, INL is collaborating to design preprocessing methods and systems that convert raw biomass into customized bioenergy feedstock commodities.



tock recipes can be as simple ing in the grain industry, or as ated as feed formulation in the livestock industry.

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Streamlining bioenergy feedstock engineering

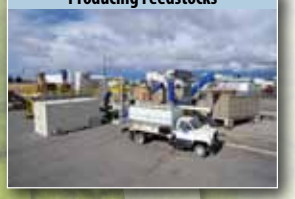
The DOE Biomass Program's feedstock research and development tools enable collaboration and sharing of feedstock development knowledge never before available. This not only could revolutionize biorefinery operations, but create innovations to supply entirely new products and markets.

The collaborative feedstock research cycle begins with lab-scale feedstock "recipe" development. Large volumes of selected formulations can then be produced using the Feedstock PDU which incorporates size reduction, preconversion, fractionation, blending and densification treatments—as called for in the feedstock recipe. The feedstock undergoes compositional and attribute characterization prior to conversion performance testing. After conversion, the performance results are then analyzed to help identify needed refinements and determine when feedstocks are ready for scale-up.

Developing Feedstock Recipes

Feedstock recipes are developed in the laboratory using analytical and process tools to explore the chemical and structural changes of preconversion, the science of formulation, and the processes of densification.

Producing Feedstocks



The DOE Office of Biomass Program's Feedstock Process Demonstration Unit (PDU) at INL is a flexible, pilot/industrial-scale research tool. It tests feedstock formulation processes, collects process data, and produces large quantities of formulated feedstocks for conversion testing.

Characterizing Feedstocks

Detailed and accurate characterization of raw biomass, process intermediates and finished feedstocks is an essential component in biomass-to-feedstock conversion—and is the best way to develop feedstocks with desired physical and chemical properties for optimal conversion performance, efficient handling and storage.

Testing Feedstocks

Sharing research and development knowledge through collaborations is necessary to develop, refine, and validate feedstock engineering processes. For this purpose, the Feedstock PDU—and associated INL laboratory facilities and capabilities—are available to support industrial and academic research and development.

Analyzing Feedstocks

Through systems modeling and analysis the physical and chemical properties, conversion performance, and process data related to desired and affordable feedstock production can be understood. Analyses are enhanced by accessing DOE's Biomass R&D Library—a database of compiled process data—that evaluates complex relationships between customized feedstock recipes and conversion performance metrics.

With funding from the DOE Biomass Program, INL designed and constructed a feedstock engineering Process Demonstration Unit (PDU) to complement laboratory tools used to develop customized feedstocks. The Feedstock PDU enables INL and its industry partners to test preprocessing technologies and advance feedstock engineering into the development phase.

For more information

Technical Contact

Kevin Kenney
Bioenergy Researcher
kevin.kenney@inl.gov
(208) 526-8098

Communications

Reuel Smith
Communications Liaison
reuel.smith@inl.gov
(208) 526-3733

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