Mobilizing Our Nation's Biomass

Providing biomass for conversion into high-quality biofuels, biopower, and bioproducts represents an economic opportunity for communities across the nation. The U.S. Department of Energy's Bioenergy Technologies Office (BETO) and its partners are developing the technologies and systems needed to sustainably and economically deliver a diverse range of biomass in formats that enable efficient use in biorefineries.

The Bioenergy Technologies Office (BETO) at the U.S. Department of Energy is taking part in the research, development, and demonstration of feedstocks' role in the billion-ton bioeconomy.

Top left: Idaho National Laboratory researchers characterize raw biomass. Top right: Researchers monitor the behavior of feedstocks in a variety of storage conditions. Bottom right: The Biomass Feedstock National User Facility allows researchers to evaluate important biomass variables such as particle size, composition, and flowability. Bottom left: A researcher determines the energy content in biomass by measuring the heating value released in combustion.

Photos courtesy of Idaho National Laboratory.

BETO works toward developing sustainable biofuels to lower U.S. reliance on imported oil, reduce greenhouse gas emissions, and enhance ecosystem services. These biofuels will also support an emerging domestic market that is capable of leveraging renewable biomass resources to create energy and biobased products with economic, environmental, social, and national security benefits—a bioeconomy. This bioeconomy will require large quantities of domestic biomass.

The broad physical and chemical diversity of suitable biomass resources means that communities across the country can reap the economic benefits of the bioeconomy. BETO is working with a variety of partners across the country to develop the technologies and systems needed to transform diverse forms of biomass into consistent, high-quality commodity products that can be efficiently handled, stored, and transported to biorefineries for processing. This work requires a complementary focus on the interfaces of feedstock supply and logistics such as:

- **Interfaces:** Such a wide variety of biomass feedstocks can create compatibility issues as the commercial-scale handling equipment and conversion processes converge. To address these issues, researchers are exploring biomass specifications and characteristics, the effects of various handling techniques, and the resulting impacts on conversion performance. Ideas such as implementing a grading system for these variable types of biomass are currently being developed.
- **Logistics:** Systems for harvesting, collecting, preprocessing, storing,

Definitions

Biomass: Any organic material that has stored sunlight in the form of chemical energy, such as plants, agricultural crops or residues, municipal wastes, and algae

Feedstocks: Any renewable, biological material that can be used directly as a fuel or converted to another form of fuel or energy product

Biorefinery: A facility that combines biomass-conversion processes and equipment to produce fuels, power, and/or value-added chemicals from biomass

Bioproducts: Any products—fuels, chemicals, or raw materials—made from renewable resources

and transporting diverse forms of biomass can operate more efficiently if the biomass they handle is fairly consistent in terms of moisture, density, particle size, and other characteristics. Multidisciplinary teams are designing and developing advanced equipment and systems to improve biomass quality, reduce costs, and increase productivity.

Currently, supply chain models generally situate the biorefinery near the feedstock resource to minimize transport cost. This, however, makes feedstocks only regionally relevant and limits the biorefinery size. An advanced feedstock supply system concept is being developed as a way to scale-up feedstock delivery operations by introducing preprocessing depots and terminals to the already-established production system and refinery.

Coordinating Interfaces

The compositional variability of biomass has a significant impact on biorefinery economics. BETO and its partners are exploring ways to increase biomass energy content while managing moisture, ash content, seasonal effects, and other characteristics that could hinder effective conversion processing.

Production Interface: Feedstock Resource Assessment

Scientists and engineers from industry, government, and academia contributed to the 2011 *U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry*. This detailed report, which provided a more comprehensive assessment than the 2005 analysis, estimated that the United States could potentially produce 85 billion gallons of biofuels—enough to replace approximately 30% of the nation's 2004 gasoline consumption. The *2016 Billion-Ton Report*, which is a joint project between the Oak Ridge National Laboratory (ORNL) and BETO, refines the cost of supply while also incorporating risk and uncertainty throughout the different regions of the United States. Through multiple economic analyses, the *2016 Billion-Ton Report* is a critical resource for landowners, businesses, and other bioeconomy participants.

Diverse agricultural, forest, algal and waste resources from across the nation can contribute to the bioeconomy and provide rural America with new economic opportunities. The *2016 Billion-Ton Report* sheds light on the economic conditions needed to help revitalize rural communities. For the first time, algal biomass is included, as assessments have shown that algae have the potential to help the bioeconomy mobilize one billion tons of biomass.

BETO's Regional Feedstock Partnership, which includes land-grant universities, industry, and the U.S. Department of Agriculture, has identified and evaluated the top biomass crops in the South Central, North Central, Northeast, and West regions by conducting multiple field trials and yield assessments.

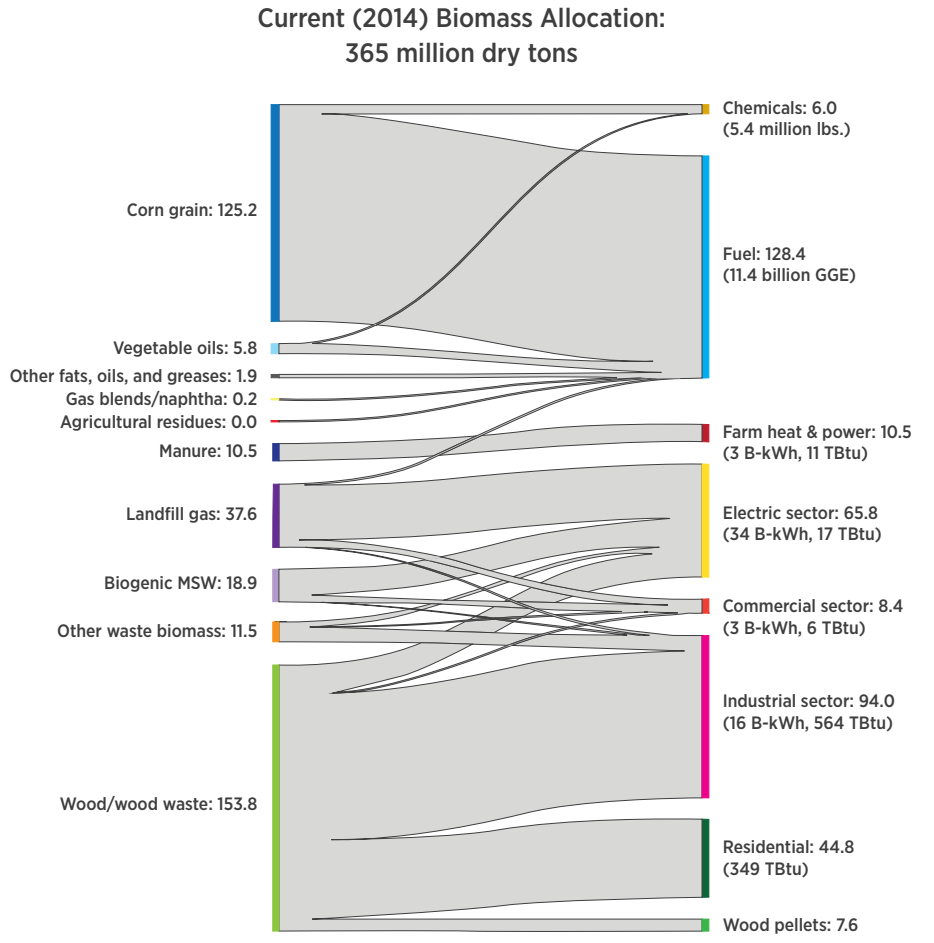

Figure 1. Sankey diagram of feedstock, sector consumption, and final product distribution. Note that biomass resources are shown on the left and their allocations are shown on the right. The size of the flow is representative of the amount of biomass allocated to that end use. *Source: 2016 Billion-Ton Report*

Units: *B-kWh – billion kilowatt-hours; GGE – gasoline gallon equivalent; MSW – municipal solid waste; TBtu – trillion British thermal units.*

Conversion Interface: Feedstock Quality and Characterization

Modeling and analysis work at the national laboratories is helping to determine feedstock specifications and enable a reliable, high-volume supply of high-quality biofuels. Researchers are using science and engineering studies to develop mathematical models and advanced biomass preprocessing systems in support of a ramp-up to commercial-scale feedstock supply. BETO is currently working with the national laboratories to make biomass a commodity available for a wider market. Currently, biomass is regionally variable, and its quality is dependent on weather. Short-term challenges involve minimizing ash content and moisture in feedstocks. Long-term challenges include finding the easiest, cheapest, and best biomass for each region.

Biomass Feedstock National User Facility

The Biomass Feedstock National User Facility's (BFNUF's) Process Demonstration Unit (PDU) is a large-scale, fully integrated feedstock preprocessing plant. Its modular construction allows industry partners to customize process flow and insert third-party equipment during process design and scale-up of bioenergy facilities. The PDU's capabilities include grinding, drying, pelletizing, cubing, torrefaction, and mechanical and chemical separation options.

The PDU also provides toll processing of a wide range of feedstock options for both BETO- and industry-funded projects. In concert with BFNUF's Bioenergy Feedstock Library and the Biomass Characterization Laboratory, the PDU provides customized technical support to leading U.S. bioenergy technology companies and bioenergy researchers. In short, BFNUF helps industry accelerate commercialization and avoid costly delays and equipment retrofits during commissioning and start-up of bioenergy facilities.

To improve biomass feedstock interfaces and overall performance, Idaho National Laboratory (INL) researchers created the Bioenergy Feedstock Library. The library is designed to provide researchers and industry with information about the physical, chemical, and conversion-performance characteristics of feedstock

Improving Logistics

Meeting future volume targets for advanced biofuels will require innovative, high-tonnage supply systems and equipment. To develop the necessary logistics, BETO has been instrumental in developing high-volume harvesting equipment, an integrated depot supply system concept, and a process demonstration unit for evaluating preprocessing impacts on biomass characteristics.

Figure 2. The Biomass Feedstock National User Facility (BFNUF) is the most complete feedstock preprocessing R&D facility in the world. Located at Idaho National Laboratory, BFNUF was developed to help overcome key technical barriers facing the U.S. bioenergy industry by investigating advanced feedstock supply and logistics, analysis and sustainability, preprocessing, and characterization. *Photo courtesy of Idaho National Laboratory.*

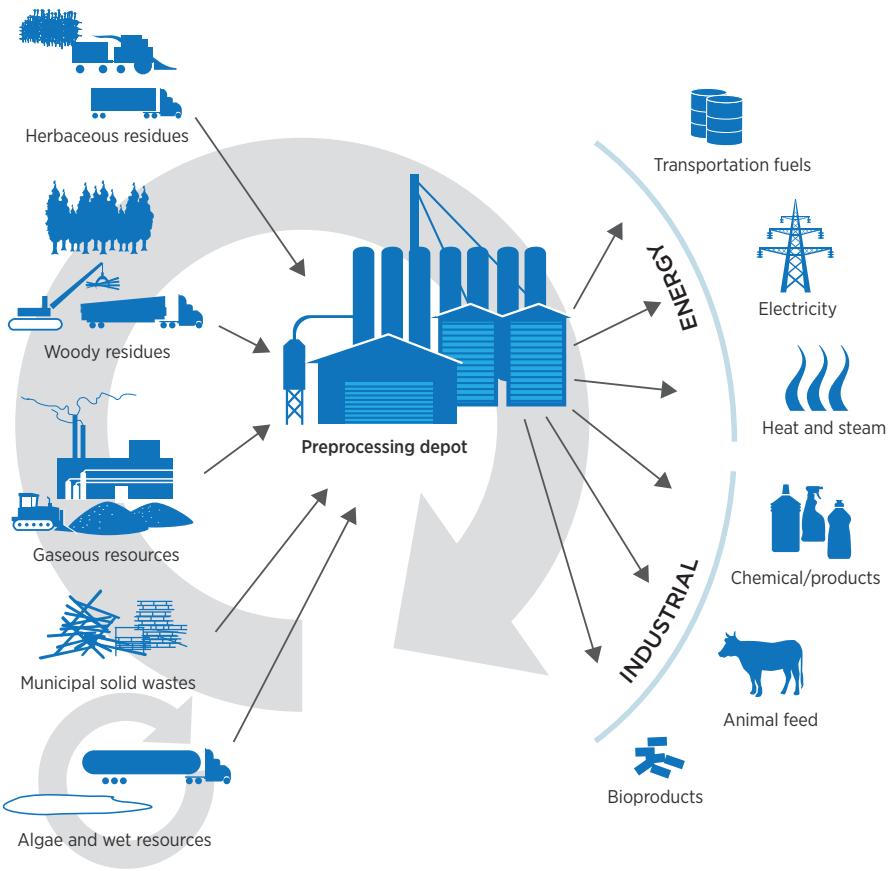

Figure 3. Schematic of the companion market strategy for catalyzing market pull for mobilization of biomass resources *(Image courtesy of Idaho National Laboratory)*

options. The library includes more than 35,000 physical samples, sample data for more than 50,000 biomass samples, and bioenergy characterization data for more than 7,500 samples. Outside researchers may securely manage their own biomass samples using the remote project management database. Security controls on each project can limit dissemination of raw data sets, but it does allow external visitors to view snapshots of important biomass characteristics for many projects. Visit https://bioenergylibrary.inl.gov/Home/ for more information.

A Uniform-Format Feedstock Supply

BETO is pursuing development of a system that links regionally distributed biomass preprocessing depots to a network of supply terminals and, ultimately, nationally integrated biorefineries (see above diagram). Currently, feedstocks are being produced only at a regional level, but the vision born from this concept will bring feedstocks to a national level to integrate time-sensitive feedstock harvesting, collection, storage, transportation, and delivery options that together will form high-quality and consistent feedstocks. Feedstock quality, cost, and transportation issues are the main questions at hand. Through exploring this concept, BETO hopes to bring uniformity and consistency to a growing market.

Future Vision: An Integrated Landscape Design

BETO is pursuing more research to integrate energy crops, such as willow, *Miscanthus*, and switchgrass, with existing cover crops, such as soybeans and corn. The energy crops would be planted in such a way that would provide benefits to the farmer, including maintaining soil nutrients, supporting erosion control, or providing shelter from high winds. Landscape design approaches under development aim to increase bioenergy production while maintaining or enhancing ecosystem and social benefits. As this sustainability consideration relates to feedstocks, multiple spatial scales are involved, including sub-fields, farms, watersheds, and entire regions. The objective is to both improve land-management principles over time and also to maintain ecosystem and social benefits such as biodiversity and food, feed, and fiber production.

Knowledge Discovery Framework

The Knowledge Discovery Framework (www.bioenergykdf.net) was established to serve as a hub for various data sets, publications, and mapping tools that support the bioenergy industry. It is synced with the Biomass Research and Development Library and provides a way to contribute data, view maps, and find data at a national, regional, local, or project level. With featured content, news, and events, it is a one-stop shop for anyone interested in bioenergy.

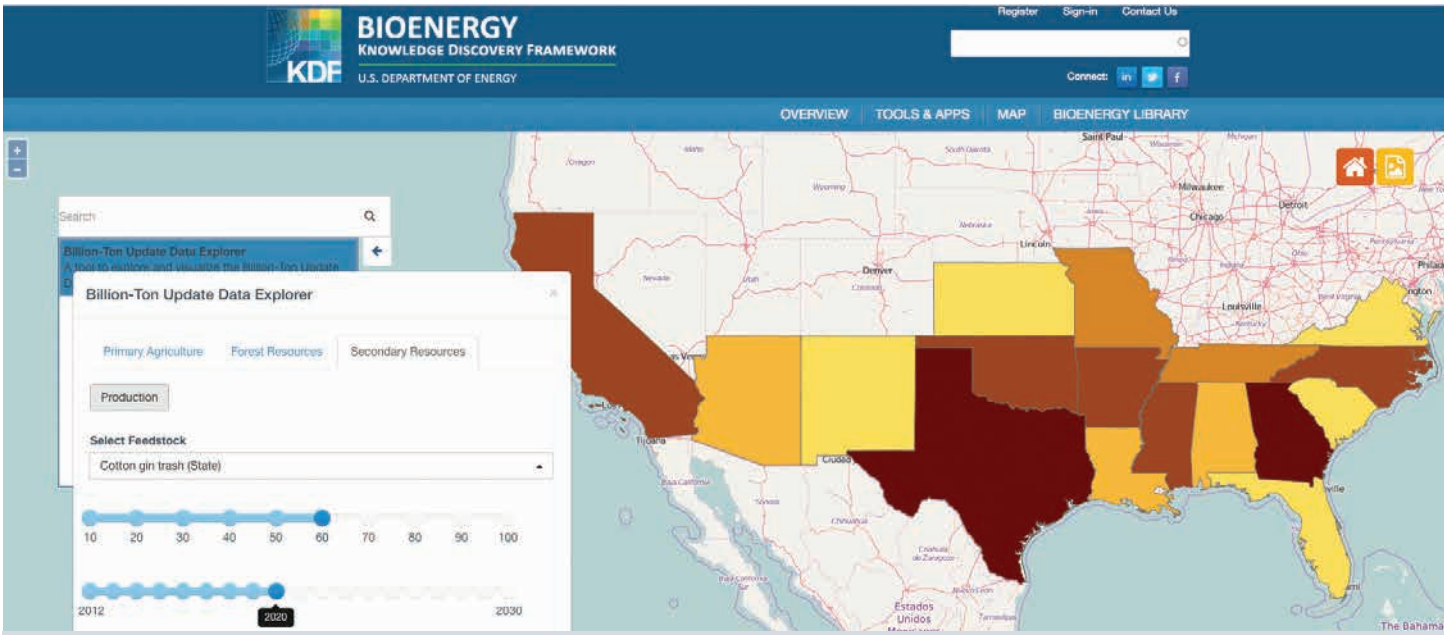

Figure 4. A screenshot of the information and interface available on the Bioenergy Knowledge Discovery Framework

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