To the Biorefinery: Delivered Forestland and Agricultural Resources

It can be challenging and costly to transport biomass feedstock supplies from the roadside, or farmgate, to a biorefinery. Given the geographic dispersion and low-bulk density of cellulosic feedstocks, cost-effective scaling of commercial biorefinery operations requires overcoming many challenges. The Biomass Research and Development Board's Feedstock Logistics Interagency Working Group identified four primary barriers related to biorefinery commercialization:

- Capacity and efficiency of harvest and collection equipment
- High-moisture content leading to degradation of biomass
- Variable biomass quality upon arrival at the biorefinery
- Costly transportation options.[1]

Further, feedstock supply systems do not currently mitigate risks such as low crop yield, fire, or competition for resource use. Delivery and preprocessing improvements will allow for the development of a commercial-scale bioenergy industry that achieves national production and cost targets.

In recent years, government-industry-academic partnerships have worked together to improve efficiency, capacity, and reliability of biomass harvesting and delivery. Manufacturers of forage, hay, and forestry equipment have responded to the needs of the bioeconomy to develop new technologies that reduce machine and labor costs. In 2009, the Bioenergy Technologies Office funded five projects to develop and demonstrate supply systems to deliver high-tonnage biomass feedstocks for cellulosic ethanol production. Focusing on crops such as corn stover, southern pine, switchgrass, miscanthus, willow, and poplar, these projects made advances in quality assessment, feedstock blending, bulk handling, storage, and compaction, as well as improved harvest and collection equipment utilization technologies and methods.

Summary

The *2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy* is the third in the *Billion-Ton* series that provides the most recent estimates of U.S. biomass supply potentially available for biorefining in the future. While both the 2011 *Billion-Ton Update* and the *2016 Billion-Ton Report* include cost estimates for the potential available supply of biomass, the 2016 report is the first in the series to include delivery and preprocessing considerations.

To illustrate how select biomass feedstocks can efficiently and cost effectively be delivered to biorefineries, the *2016 Billion-Ton Report* presents a scenario analysis to incorporate transportation and logistics costs to the final feedstock prices. In the proposed delivery system, feedstocks will be transformed into intermediate products at a regional processing facility before being converted to biofuel, biopower, or bioproducts at a biorefinery. In the future, a feedstock supply system that includes a preprocessing depot to aggregate multiple feedstock sources and multiple end uses could transform raw biomass into a stable commodity suitable for long-distance transport and handling in existing infrastructure.

The objective of the proposed future feedstock supply system (illustrated below) is to transform raw biomass into stable, tradeable commodities suitable for long-distance transport and handling in existing infrastructure.

The *2016 Billion-Ton Report* presents the assumption that a traditional delivery system focusing on just one feedstock source and a single end use will remain in place for the near term. Given this assumption, an estimated 217 million tons of biomass could be available at a delivered cost less than $84 per ton (assuming a roadside/farmgate price of $60/ton). In the long term, assuming the development of the proposed delivery system, as well as additional feedstocks and increasing yields, approximately 467 million tons per year could be delivered at the cost target of $84/ton. In the long-term, high-yield scenario, total feedstock quantities increase to 825 million tons at a delivered cost of less than $84/ton. A high-yield scenario was not considered for the near-term resources, given that there would be only minimal impact of the advanced feedstock supply system within a short time frame.

Approach

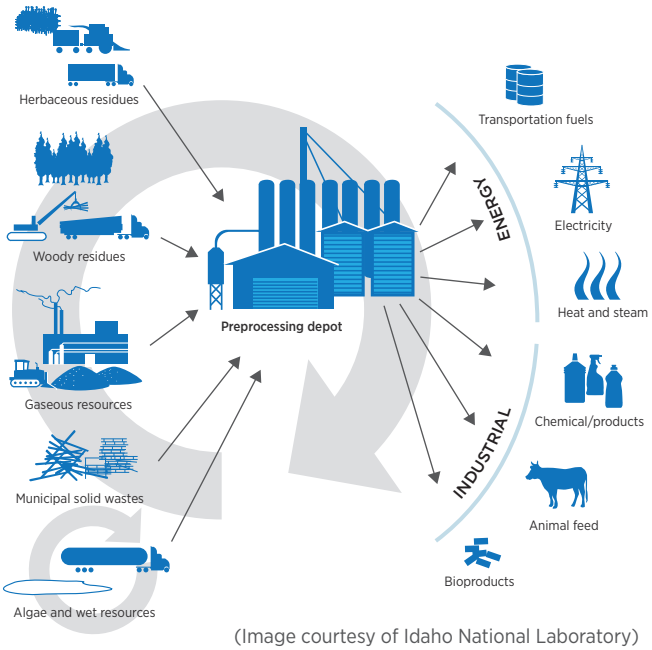
The scope of analysis in the *2016 Billion-Ton Report* is expanded beyond previous reports to characterize the potential economic availability of biomass resources as delivered to biorefineries. In order to develop the proposed feedstock supply system concept, the Bioenergy Technologies Office held an Advanced Feedstock Supply System Validation Workshop in 2015 to solicit input from stakeholders.[2] A guiding principle in this process was incorporating active quality-management technologies to transform raw feedstocks into a tradeable commodity. The proposed delivery system involves the development of regional depots within a short distance (5–10 miles) from biomass production sites. At these preprocessing depots, either herbaceous or woody feedstocks would be converted into an intermediate commodity, such as feedstock pellets, that can be handled in existing storage, conveyance, and transportation infrastructure.

A spatially explicit resource allocation modeling system was utilized to determine the price and quantity of delivered feedstock supplies across the United States. The Supply Characterization Model simulates feedstock transportation from a source to a destination facility and includes five logistics cost inputs, including production costs; other logistics costs such as storage, preprocessing, and handling; time transportation cost; distance transportation cost loaded; and distance

[1] Biomass Research and Development Board. 2010. Biofuel Feedstock Logistics: Recommendations for Research and Commercialization. A Report by the Feedstock Logistics Interagency Working Group. U.S. Department of Energy, Washington, D.C.

[2] Jacobson, et al. U.S. Department of Energy. 2015. "Advanced Feedstock Supply system Validation Workshop Summary Report". INL/EXT-108930. Idaho National Laboratory, Idaho Falls, ID. 140p.

Proposed future feedstock supply system for transforming raw biomass into stable, tradeable commodities suitable for long-distance transport and handling in existing infrastructure



(Image courtesy of Idaho National Laboratory)

Total Feedstocks Available at Average Roadside Cost and Delivered Costs of $84 and $100 per Ton

	Near term	Long term
Base-Case Yield Scenario (million tons)		
Roadside at ≤ $60	310	679
Delivered ≤ $84	217[a]	467
Delivered ≤ $100	217	564
Unused	93	114
High-Yield Scenario (million tons)		
Roadside at ≤ $60	NA	985
Delivered ≤ $84		825
Delivered ≤ $100		825
Unused		160

[a] *Near-term availability of feedstocks delivered at less than $84/ton diverges from DOE targets as (1) previous analyses were based on BT2 roadside availability assessments, and (2) this analysis does not include all biomass sources.*

transportation cost.[3,4] The modeling also involved selecting utilization facility locations iteratively, based on minimizing the average total feedstock cost, until all of the available supply had been assigned a destination facility.

The *2016 Billion-Ton Report* considers traditional and proposed advanced feedstock supply systems independently. Recognizing that future delivery systems will evolve over time to include advanced depot-based preprocessing technologies, the near-term scenarios were based on the utilization of the traditional delivery method, while the long-term scenarios were based on the utilization of the preprocessing depot system. It is expected that the proposed feedstock supply system will involve additional costs related to feedstock preprocessing. However, through improved feedstock quality and decreased risk, cost savings are anticipated.

The *2016 Billion-Ton Report* estimates the potential economic availability of forestland and agricultural biomass resources at the county level. These estimates are input in modeling near-term and long-term delivered feedstock availability. Given the report's economic-engineering costing approach, the modeled delivered cost does not include for-profit, transaction, or other business costs; thus, it is not intended to indicate full prices paid by biorefineries.

The Path Forward

Developing advanced feedstock supply systems is an important aspect of building a billion-ton bioeconomy. The *2016 Billion-Ton Report* makes significant advances to build on previous research and experiences with conventional feedstock supply systems. Future research and development will serve to better analyze feedstock supply systems and reduce the delivered costs of biomass feedstock. Also, future analysis will consider the coexistence of both traditional and advanced biomass delivery systems, specifically how adopting advanced systems can enable industry expansion in locations with previously unfavorable feedstock production conditions.

[3] Webb, E., et al. 2014. Spatial Analysis of Depots for Advanced Biomass Processing.

[4] Cafferty, K.G. et al. (2014). Feedstock Supply System Design and Economics for Conversion of Lignocellulosic Biomass to Hydrocarbon Fuels - Conversion Pathway: Fast Pyrolysis and Hydrotreating Bio-oil Pathway, 2017 Design Case. Idaho National Laboratory, Idaho Falls ID.

This fact sheet refers to the following documents

U.S. Department of Energy. 2016. *2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy*. M. H. Langholtz, B. J. Stokes, and L. M. Eaton (Leads), ORNL/TM-2016/160. Oak Ridge National Laboratory, Oak Ridge, TN. 448p.

Download and view the report, explore its data, and discover additional resources at www.bioenergykdf.net.

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