# Summary and Comparison of the *2016 Billion-Ton Report* with the 2011 *U.S. Billion-Ton Update*

## Summary

In terms of the magnitude of the resource potential, the results of the *2016 Billion-Ton Report* (BT16) are consistent with the original *2005 Billion-Ton Study* (BTS) and the 2011 report, *U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry* (BT2).

An effort was made to reevaluate the potential forestland, agricultural, and waste resources at the roadside, then extend the analysis by adding transportation costs to a biorefinery under specified logistics assumptions to major resource fractions.

This report shows the potential availability of more than 1 billion dry tons[1] of biomass for bioenergy and coproducts in the conterminous United States, a result that is consistent with both BTS and BT2. By 2040, at a price of $60 per dry ton at roadside,[2,3] total currently used and potential new supplies range from 1.2 billion tons (base-case scenario) to 1.5 billion tons (high-yield scenario).

A scenario study of major herbaceous and woody feedstocks potentially available in 2040 suggests that more than half of this supply is available at weighted-average delivered costs of $84 per ton or less,[4] although the prices of woody biomass are derived from demand, not supply, potential. In addition to the biomass resources potentially available from forestland and agricultural lands, about 365 million dry tons of currently used biomass resources and 142 million dry tons of waste resources have been identified.

For the first time, algae have been included in the resource assessment and have substantial potential. Algae have a higher fuel yield per unit of biomass than terrestrial feedstocks. At higher farmgate prices, additional algal biomass could be available, but the prices will need to decrease for the full potential to be realized.

### Key conclusions and implications include the following:

- Biomass availability is a function of market, innovation, and time.
- Agricultural residues, wastes, and forest resources are available now; energy crops offer growth potential in the coming years.
- Forestry resources are regionally specific and subject to macroeconomic and local market forces.
- Prices for delivered supplies are largely accessible, though more logistics systems research is needed.
- All identified potential supplies are contingent upon prices.

## Approach

Biomass availability is dependent on many factors, including market, innovation, and time. As with BT2, terrestrial biomass supply increases with increasing price, higher yields, and over time. A major difference between BT2 and BT16 is the later start date of energy crop simulation, starting in 2014 in BT2 and in 2019 in BT16. However, out-year results of both energy crops and total supplies are similar for both studies under base-case and high-yield scenarios.

BT16 uses the same modeling framework as was in BT2 to quantify biomass resources from agricultural lands potentially available at the farmgate. Thus, many of the same key assumptions discussed in the conclusions section of BT2 are also applicable to this report. Deviation from these assumptions impacts potential future availability. Key underlying assumptions of the agricultural analyses include prices, the start year of energy crop contracts, U.S. Department of Agriculture agricultural projections, and base-case and high-yield scenarios.

To achieve commercial-scale production as represented in the base-case (1% yield improvement annually) and high-yield (2%–4%) scenarios, many market conditions must align to reduce risk and promote adoption. A number of these factors, such as contract length, cost share, and participation incentives, affects farmer participation in biomass markets.

Overall results depend on the selection of parameters and the underlying assumptions, while changing technical or economic variables changes the tonnage amounts or the subsequent timeline required to achieve the tonnage amount. The conclusions chapter of BT2 discusses the significance of underlying assumptions in that analysis, while the BT16 has modified some of these assumptions for greater precision. For example, tillage practice is now endogenously modeled; more conservative operational constraints on residue harvest are added; and energy crops on pasture land are constrained based on a precipitation gradient rather than the 100th meridian. These and other refinements are described in detail in appendix C of the report.

New to this report is the analysis of potential supplies delivered to biorefineries. In addition to the aforementioned

[1] All tons and prices per ton are reported on a dry weight basis unless otherwise specified.

[2] All prices are reported as 2014 real dollars.

[3] "Roadside" or "farmgate" refers to forest and agricultural resources after production and harvest, but before transportation and logistics.

[4] The $84 target is derived from the 2016 Bioenergy Technologies Office Multi-Year Program Plan in 2014 dollars (inflated from $80 per dry ton in 2011 dollars).


assumptions relating to biomass production and harvest, results of the logistics analysis are subject to key assumptions about delivered and roadside supplies, the evolution to advanced logistics systems, and the inclusion of multi-modal logistical options (such as transportation by rail or barge).

## The Path Forward

These results can and should be used to inform strategies to mobilize bioenergy markets and the biomass resources they will require. Looking to the history of the commoditization of conventional crops can provide insight into the interrelationships between supplies, markets, and technologies.

Research and development can improve profits and incentivize investment, which in turn, can grow market demand. Growing market demand can lead to increased feedstock supplies and more research and development. This cycle of investment, market growth, and feedstock supply expansion has become self-sustaining in commodity crop markets. To date, U.S. Department of Energy investments, such as the Regional Feedstock Partnership, pioneer biorefineries, and high-tonnage feedstock logistics projects have begun this cycle of investment, market growth, and feedstock supply expansion.

From a systems perspective, the cheapest feedstock may or may not be the most cost effective. Algal biomass is more expensive than terrestrial feedstocks, but is more readily convertible to a biofuel; biomass energy crops are generally more expensive than crop residues, but may have lower ash content; biomass delivered from an advanced logistics system may be more expensive than from a conventional system, but may offer economic benefits of supply reliability, consistency, and improved handling. This study is limited by product-agnostic assumptions, but future analyses with better information about conversion needs and optimization across the supply chain should incorporate these benefits.

Results in this report indicate the United States holds great potential for production of biomass feedstocks. In broad terms, a diversity of biomass resources could be tapped that could double or triple current levels of biomass use for bioenergy, producing approximately 1.0 billion–1.5 billion tons of biomass annually for energy and co-products. Realization of this potential is contingent upon a mix of economic factors, such as markets, investment, and innovation, and were not considered in volume 1. An assessment of the environmental sustainability of the biomass potential described here is presented in the upcoming volume 2 of this report.

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.

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