Billion Ton 2016 Preview*

Biomass R&D Board
Technical Advisory Committee
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*Based on May 27, 2015 BETO Webinar

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History and Accomplishments

Billion-Ton Study (BTS), 2005
• Technical assessment of agricultural and forestry systems to supply low-valued biomass for new markets
• Identified adequate supply to displace 30% of petroleum consumption; i.e. physical availability

Billion-Ton Update (BT2), 2011
• Quantified potential economic availability of feedstocks for 20-year projection
• Publicly released county-level supply curves for 23 candidate feedstocks through Bioenergy Knowledge Discovery Framework.
Preamble to Billion-ton Update

• Resource assessment – not demand estimates
• Excluded algal feedstocks
• Included “major” feedstocks
• Costs were only to roadside/farmgate
• No specified product end use or conversion process
• Raw material in form as described with losses only up to roadside
• Does not represent full cost or actual, usable tonnage at facility
Baseline scenario

- Current combined resources from forests and agricultural lands total about 473 million dry tons at $60 per dry ton or less.
- By 2030, estimated resources increase to nearly 1.1 billion dry tons.

High-yield scenario

- By 2030, total resource ranges from 1.4-1.6 billion dry tons annually.
- No high-yield scenario was evaluated for forest resources.
Billion-ton Results

2022
Baseline scenario
$60 \text{ dry ton}^{-1}$

$529 \times 10^6 \text{ dt}$

Potentially Available Biomass Resources
Includes all potential primary agricultural resources and primary and secondary forestry resources excluding Federal Lands (when available) at $80 \text{ per dry ton or less:}$
Agricultural Residues of Major Crops, Logging Residues, Simulated Forest Thinnings, Other Removal Residues
Treatment thinnings (other forestland), Conventional Pulped wood to Bioenergy, Woody Municipal Solid Waste, Unused Mill Residue

2022 County-level Estimates


Baseline Scenario
Dry Tons/Year

0 - 1,000
1,001 - 25,000
25,001 - 50,000
50,001 - 100,000
100,001 - 250,000
250,001 - 500,000
500,001 - 1,000,000

Additional Source Information:

5 | Bioenergy Technologies Office
How much is a billion tons? is 1-Billion

One billion tons of biomass would fill the Dallas Cowboys AT&T Stadium 1600 times.

(assumed average biomass density 12 lb / ft$^3$)

Dallas Cowboys AT&T Stadium – Arlington, Texas
A BILLION DRY TONS OF BIOMASS HAS THE POTENTIAL TO PRODUCE

1.5 MILLION JOBS and keep about $200 BILLION dollars in the U.S. every year.

92 BILLION kWh of electricity to power 8 MILLION households.

60 BILLION gallons of biofuels displacing almost 30% of all transportation fuels.

50 BILLION POUNDS of biobased chemicals and bio-products, replacing a significant portion of the chemical market.

reductions of CO₂ emissions by 500 MILLION TONS a year.

Numbers being updated

Projection based on the 2011 Billion Ton Study Report

1. Accelerate research & technology development
2. Develop production, conversion and distribution infrastructure
3. Deploy technologies
4. Create markets and commercial methods

### Global Biomass Potential

<table>
<thead>
<tr>
<th>Region</th>
<th>Energy Crops (Million Acres)</th>
<th>Supply Potential (Billion Dry Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>62-222</td>
<td>0.4-1.5</td>
</tr>
<tr>
<td>USA 2005 BTS</td>
<td>74</td>
<td>1.1</td>
</tr>
<tr>
<td>USA 2011 BTS</td>
<td>63</td>
<td>1.4</td>
</tr>
<tr>
<td>Latin America</td>
<td>299</td>
<td>1.5</td>
</tr>
<tr>
<td>China &amp; India</td>
<td>212</td>
<td>1.7</td>
</tr>
<tr>
<td>Australia</td>
<td>-</td>
<td>&lt;4M</td>
</tr>
</tbody>
</table>

From Bauen et al., 2009. Timeframes are 2017-2030 and Table 6.4, Billion-ton Update.
• Biomass can provide 27% of world’s transportation fuel by 2050
• Around 3 billion tonnes of biomass per year will be needed/required
• Requires approximately 1 billion tonnes of biomass residues and wastes
• Production needs to be supplemented by production from around 100 million hectares of land - around 2% of total agricultural land - three-fold increase
• Need for the biofuels yield to increase 10x
High-Level Goals of 2016 Billion-Ton Report (BT16)

• Assess current demand of commercial biomass-to-energy feedstocks
• State-of-science biomass potential supply to 2040
  • Agricultural, forestry, algal, and waste resources
  • From farm to roadside to regional delivery points
• Environmental sustainability analysis of potential supply
### Major Differences: Three National Assessments

**Purpose of the 2016 Billion-Ton Update**

- Evaluate biomass resource potential
- Improve and expand upon the previous studies
  - Greater detail of dedicated energy crop systems; revised BMP
  - Include algae resources
  - Analysis of regional transportation costs
  - Volume 2 will feature risk assessment and environmental sustainability analysis covering air quality impacts, greenhouse gases, and water quality

<table>
<thead>
<tr>
<th></th>
<th>2005 BTS</th>
<th>2011 Update</th>
<th>2016 Update</th>
</tr>
</thead>
<tbody>
<tr>
<td>National estimates – no spatial information</td>
<td>County-level with aggregation to state, regional and national levels</td>
<td>County-level with regional analysis of potential delivered supply</td>
<td></td>
</tr>
<tr>
<td>No cost analyses – just quantities</td>
<td>Supply curves by feedstock and county – farmgate/forest landing</td>
<td>More detailed costing analysis to provide cost of production along supply chain to new facilities</td>
<td></td>
</tr>
<tr>
<td>No explicit land use change modeling</td>
<td>Land use change modeled for energy crops</td>
<td>LUC modeled and accessed for soil carbon impacts</td>
<td></td>
</tr>
<tr>
<td><strong>2005</strong> USDA agricultural projections; <strong>2000</strong> forestry RPA/TPO</td>
<td><strong>2010</strong> USDA agricultural projections; <strong>2010 FIA inventory</strong>; <strong>2007</strong> forestry RPA/TPO</td>
<td><strong>2015</strong> USDA agricultural projections; <strong>2012</strong> USDA Census</td>
<td></td>
</tr>
<tr>
<td>Crop residue removal sustainability addressed from national perspective; erosion only</td>
<td>Crop residue removal sustainability modeled at soil level (wind &amp; water erosion, soil C)</td>
<td>Crop residue considered in scenario of integrated landscape management</td>
<td></td>
</tr>
<tr>
<td>Erosion constraints to forest residue collection</td>
<td>Greater erosion plus wetness constraints to forest residue collection</td>
<td>Volume 2 will feature robust analysis of environmental sustainability</td>
<td></td>
</tr>
</tbody>
</table>
Two-Volume Approach

- Volume 1: Resource analysis
  - Supply curves at field/forest level and delivered to collection point
  - June 2016 publish target
- Volume 2: Environmental sustainability analysis
  - Air quality, water, GHG, biodiversity analysis
  - Climate change impacts
  - September 2016

Five USDA-ARS energycane varieties planted at a Mississippi State University field site sponsored by DOE in the Regional Feedstock Partnership. (Award # GO85041). Photo Credit: Steve Thomas
Additional feedstocks: Algae and MSW

Algae Supply Curve (ASC) Project

- Goal: Quantify the potential algal feedstock production and cost, based on collocated industry-sourced alternative resource supplies to support inclusion with terrestrial feedstock supply and price projections (FSPPs).

- FY15Q4: Generate supply curves illustrating economic availability of algae feedstocks under scenarios involving collocation of algae production with CO2 from ethanol plants and power plants. Anticipate that both open-pond systems and photobioreactors will be included. Supply curves will be used in Billion-Ton 2016.

"Garbage" fraction of MSW

- 135 million green tons/year landfilled, (about half of BioCycle 2010, 42% of PNNL's 2012 estimate).
- Regional tipping fees from $20-$50. Adding sorting and processing costs to improve the supply curves in BT2016.

![pie chart showing organic waste composition](chart.png)
Integrating Sustainability Considerations into the Resource Analysis

Greenhouse gas emissions

Productivity

Soil quality

Biological diversity

Water quality and quantity

Air quality
Feedstock cost is the 2nd largest source of cost variability in 2014 Thermochemical Minimum Fuel Selling Price (-7.8% to +15.7%).

In Biochemical and Thermochemical process design cases (Technoeconomic Analysis), feedstocks costs consistently account for about 1/3 of Minimum Fuel Selling Price (MFSP).

Cost variability = RISK
SGI Regional Feedstock Partnership Field Trial Network

110+ Field Trial Locations

Disclaimer: This map is intended for visual representation only. Many field trials occur within the same research location and may not be indicated on the map. Users of this information should contact the Department of Energy Golden Field Office for additional data information.
National Crop Yield and Variability Modeling

SSURGO Soil Maps
PRISM Climate Maps
Biomass Yield

Average Annual Yield Potential, 1981 - 2010
Lowland RyeGrass

Percent of Maximum Yield (Relative Yield Map)

PRISM-EM Crop Suitability Model

Interface with Crop Experts

KDF Field Trial Database
Enhanced Energy Crop Potential Yield

Herbaceous Energy Crops

Woody Crops

Manuscript in preparation by SGI Field Trial and Resource Assessment Teams

Credit: Oregon State University PRISM Climate Group
Models

- CENTURY: Soil carbon, nitrogen, phosphorus, and sulfur model.
- F-PEAM: Feedstock Production Emissions to Air Model
- ForSEAM: Forest Sustainable and Economic Analysis Model
- GREET: The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model
- POLYSYS: Policy Analysis System
- SRTS: Subregional Timber Supply Model
- SWAT: Soil and Water Assessment Tool
- WATER: Water Assessment for Transportation Energy Resources
Collaborators

- Lead organization: ORNL
- Sustainability analysis led by national labs: ANL, INL, NREL, ORNL

Hybrid Poplar Stand in Oregon
Photo Credit: Laurence Eaton and Mike Halbelib