Bioenergy Technologies Office

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

2017 BETO Project Peer Review

Overview of 2016 Billion-Ton Report Volume 1

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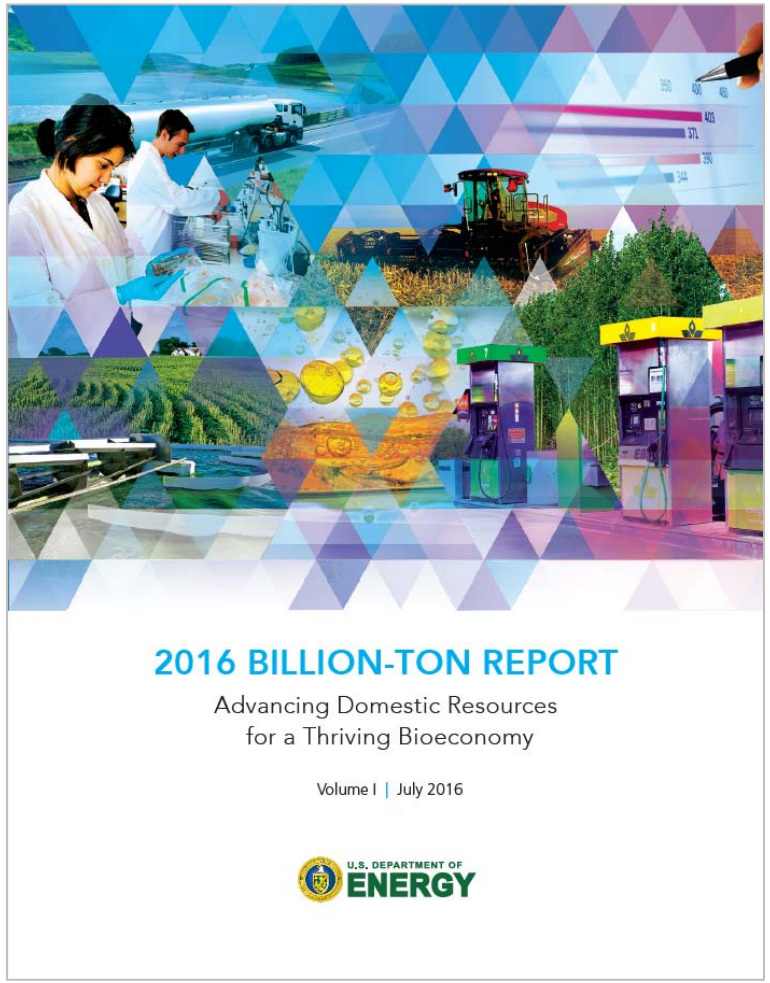
***On behalf of entire team**

Major Differences

- Purpose of the 2016 *Billion-Ton Report*
  - Evaluate biomass resource potential
  - Improve and expand upon the previous studies
    - Greater detail of dedicated energy crop systems, revised BMP
    - Analysis of logistics costs to deliver potential supply
    - Resource assessment will include risk analysis and new feedstocks, including algae, miscanthus, eucalyptus, and energy cane.
    - Volume 2 features environmental analyses including greenhouse gases, water, air emissions, and biodiversity

2005 Study	2011 Update	2016 Report
National estimates – no spatial information	County-level with aggregation to state, regional and national levels	County-level with regional analysis of potential delivered supply
No cost analyses – just quantities	Supply curves by feedstock by county – farmgate/forest landing	More detailed costing analysis to provide cost of production along supply chain to new facilities
No explicit land use change modeling	Land use change modeled for energy crops	LUC modeled and accessed for soil carbon impacts
Long-term, inexact time horizon (2005; ~2025 & 2040-50)	2012 – 2030 timeline (annual)	2016-2040 timeline (annual)
2005 USDA agricultural projections; 2000 forestry RPA/TPO	2010 USDA agricultural projections: 2010 FIA inventory and 2007 forestry RPA/TPO	2015 USDA agricultural projections; 2012 USDA Census
Crop residue removal sustainability addressed from national perspective; erosion only	Crop residue removal sustainability modeled at soil level (wind & water erosion, soil C)	Crop residue considered in scenario of *integrated landscape management*
Erosion constraints to forest residue collection	Greater erosion plus wetness constraints to forest residue collection	Volume 2 includes robust analyses of environmental effects
100th meridian used for land conversion constraint; permanent pasture excluded	100th meridian used for land conversion constraint; permanent pasture allowed to convert at low rate	Precipitation-based constraint (25”/year) applied; permanent pasture allowed to convert at low rate

Outline of *2016 Billion-Ton Report Volume 1*



Volume 1

- Currently Used Resources (biomass for biopower, bioproducts, biochemicals, and biofuels)
- Roadside Forest Resources
- Farmgate Agricultural Resources
- Secondary and Waste Resources
- To The Biorefinery: Delivered Resources
- Microalgae

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Author and Contributor Organizations*

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- USDA Forest Service

**And many more!*

Other Contributors

- BCS, Inc.
- Sun Grant Regional Partnership
- University of Tennessee
- SUNY-Syracuse
- South Dakota State University
- Oregon State University
- Oak Ridge National Laboratory
- National Renewable Energy Laboratory
- Environmental Protection Agency
- USDA Forest Service
- USDA Agricultural Research Service
- USDA National Institute of Food and Agriculture
- USDA Office of Energy Policy and New Uses

Multiple Reviewers (28) attended Volume I workshop

Government	Academia	Non-Government Organizations	Industry
• Environmental Protection Agency • Department of Energy • Federal Aviation Administration	• University of California - Davis • University of Georgia • North Carolina State University • University of Arizona • University of Minnesota • Iowa State University • University of Illinois	• National Council for Air & Stream Improvement • Union of Concerned Scientists • Pinchot Institute	• Shell • Forest Concepts • Mater Engineering • GreenWood Resources • AGCO Corp. • Antares • Resource Dynamics • Sapphire Energy • Qualitas Health • Algenol Biotech LLC

Key Assumptions/Issues

- Models meet food, forage, feed, and fiber (even export) requirements to 2040.
- Current uses are estimated to 2017, held constant to 2040, and all increases become part of the estimated potential.
  - Examples of current uses: solids, fuels for biopower and heat, corn-starch ethanol, lignocellulosic biofuels, biodiesel, and biochemicals.
- Supply cost curves are to farmgate/roadside with case-study estimates to throat.
- Biomass potential is a function of cost-to-roadside, year, and scenario.
  - Base-case scenario:
    - Agriculture: 1% annual increase in yield through 2015-2040
    - Forestry: moderate housing demand-low wood energy demand
  - High-yield scenario:
    - Agriculture: 3% annual increase in yield through 2015-2040
    - Forestry: high housing demand – high wood energy demand
- Agriculture and forest lands are held constant but allocation changes occur in agriculture. Conservation Reserve Program lands are excluded.
- Underlying assumptions are intended to be “conservative” and have built-in “sustainability” considerations.

Models/Data Used in BT16 Volume 1

Models

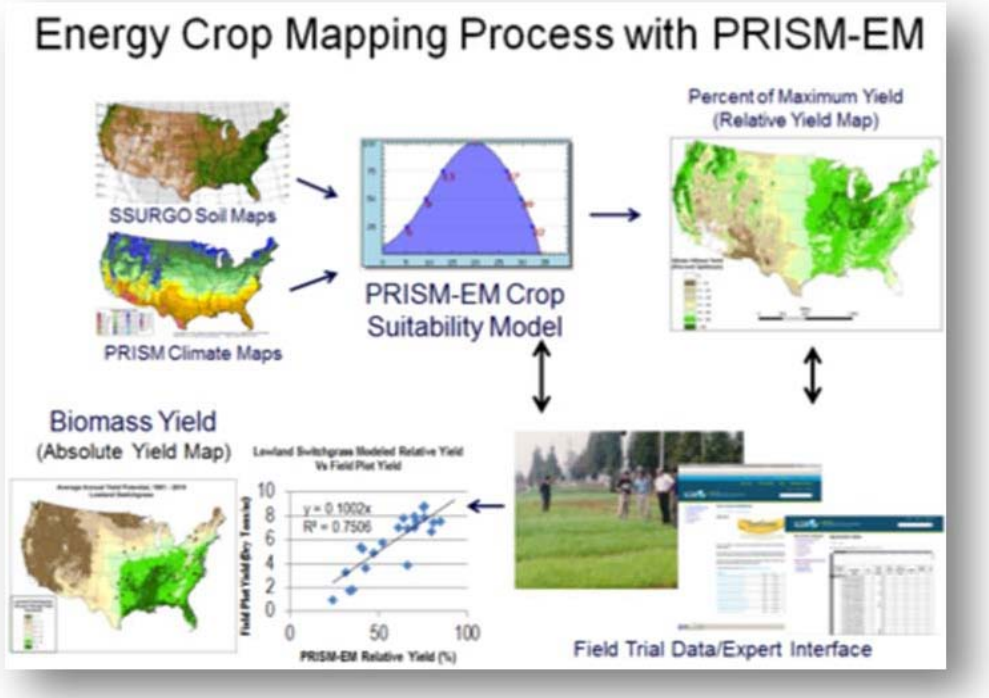
- POLYSYS: Policy Analysis System
- ForSEAM: Forest Sustainable and Economic Analysis Model
- SRTS: Subregional Timber Supply Model

Data

- USDA Long-Term Agricultural Projections
- U.S. Forest Service RPA (10-year forest assessment) and FIA
- EIA Monthly Energy Review, Annual Energy Outlook, Consumption Surveys and other data
- PRISM (climate) and SSURGO (soils) high resolution data
- Yield maps from field trials on energy crops, including the SunGrant Regional Feedstock Partnership.

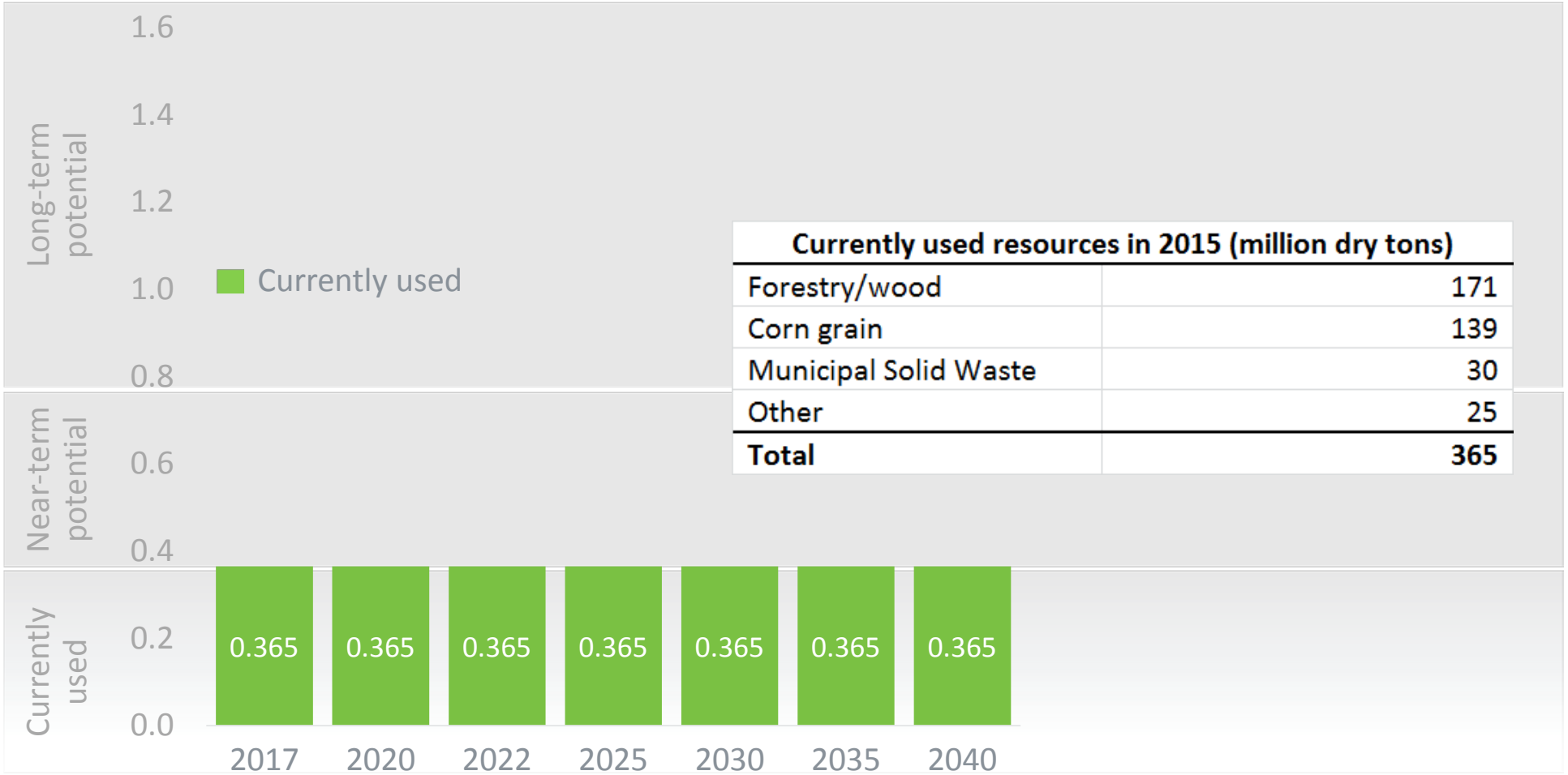
Objectives of Volume 1

- Estimate current use of biomass for energy
- Apply state-of-the art science to estimate resource potential
- Simulate potential supply – not a supply or demand prediction



Current and Potential, Base-case, $60/dt

Billions of Dry Tons per year



Currently used resources in 2015 (million dry tons)	
Forestry/wood	171
Corn grain	139
Municipal Solid Waste	30
Other	25
Total	**365**

Current and Potential, Base-case, $60/dt

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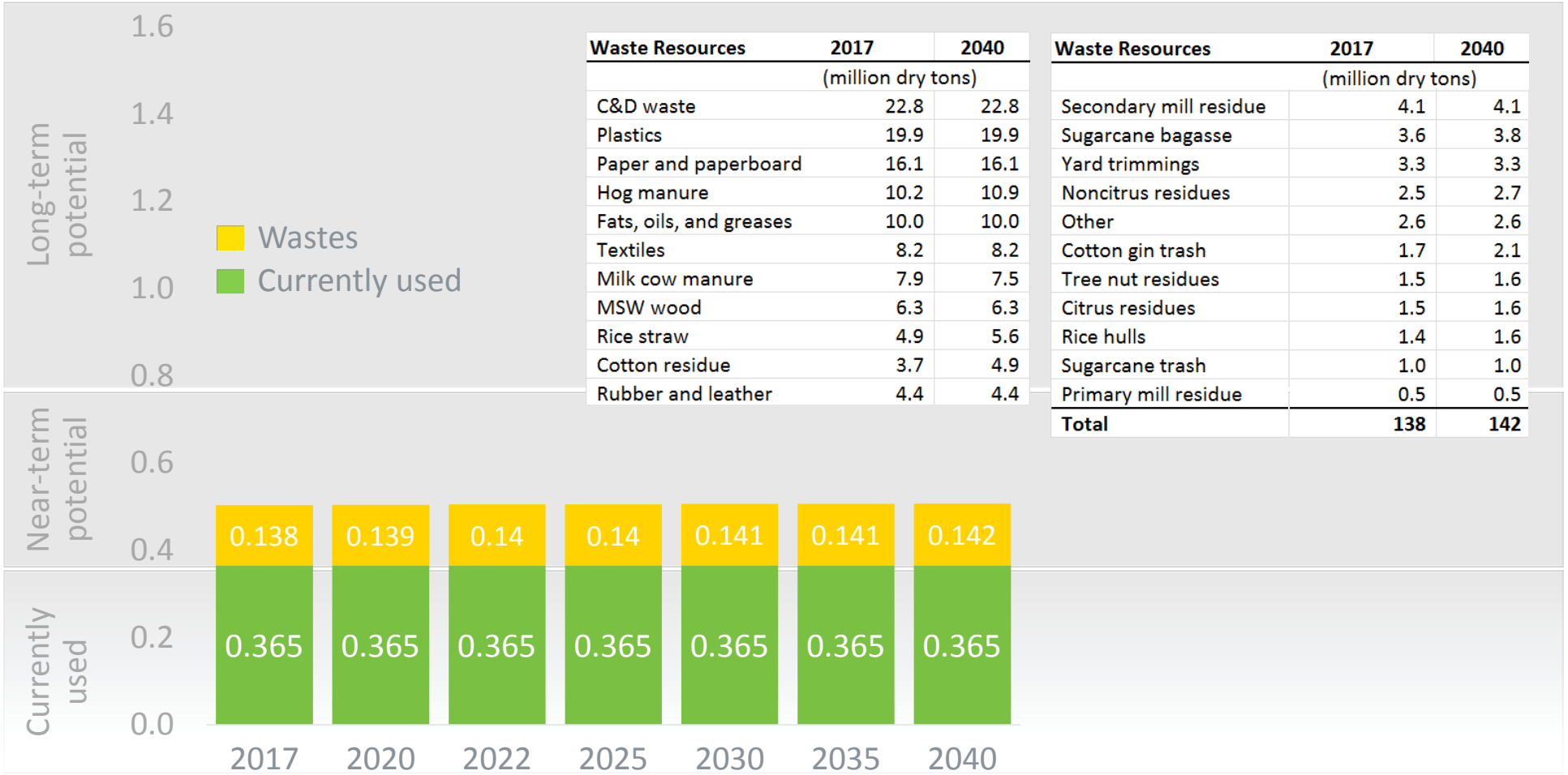
Billions of Dry Tons per year

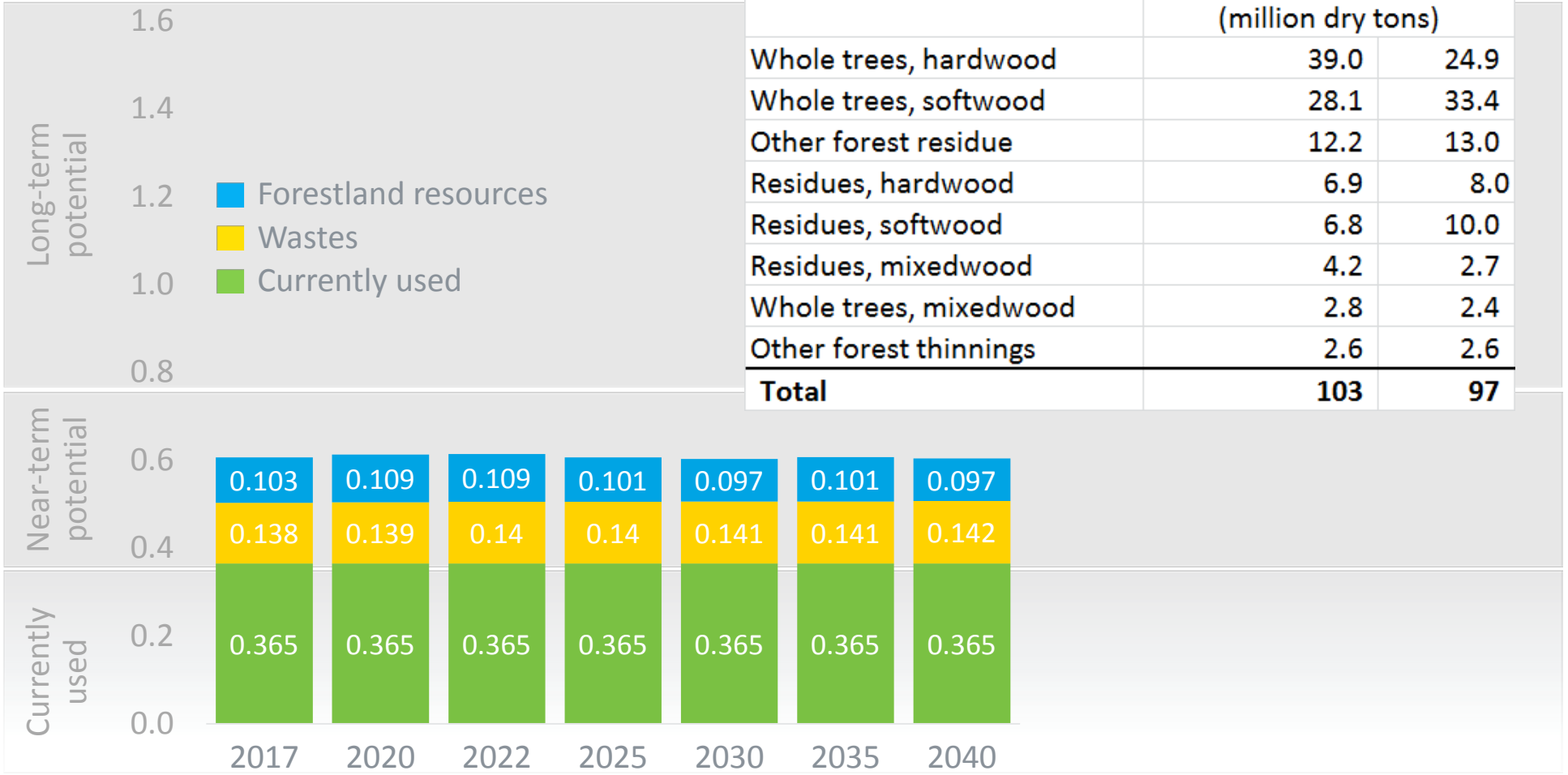


Waste Resources	2017	2040
	(million dry tons)	
C&D waste	22.8	22.8
Plastics	19.9	19.9
Paper and paperboard	16.1	16.1
Hog manure	10.2	10.9
Fats, oils, and greases	10.0	10.0
Textiles	8.2	8.2
Milk cow manure	7.9	7.5
MSW wood	6.3	6.3
Rice straw	4.9	5.6
Cotton residue	3.7	4.9
Rubber and leather	4.4	4.4

Waste Resources	2017	2040
	(million dry tons)	
Secondary mill residue	4.1	4.1
Sugarcane bagasse	3.6	3.8
Yard trimmings	3.3	3.3
Noncitrus residues	2.5	2.7
Other	2.6	2.6
Cotton gin trash	1.7	2.1
Tree nut residues	1.5	1.6
Citrus residues	1.5	1.6
Rice hulls	1.4	1.6
Sugarcane trash	1.0	1.0
Primary mill residue	0.5	0.5
Total	**138**	**142**

Current and Potential, Base-case, $60/dt

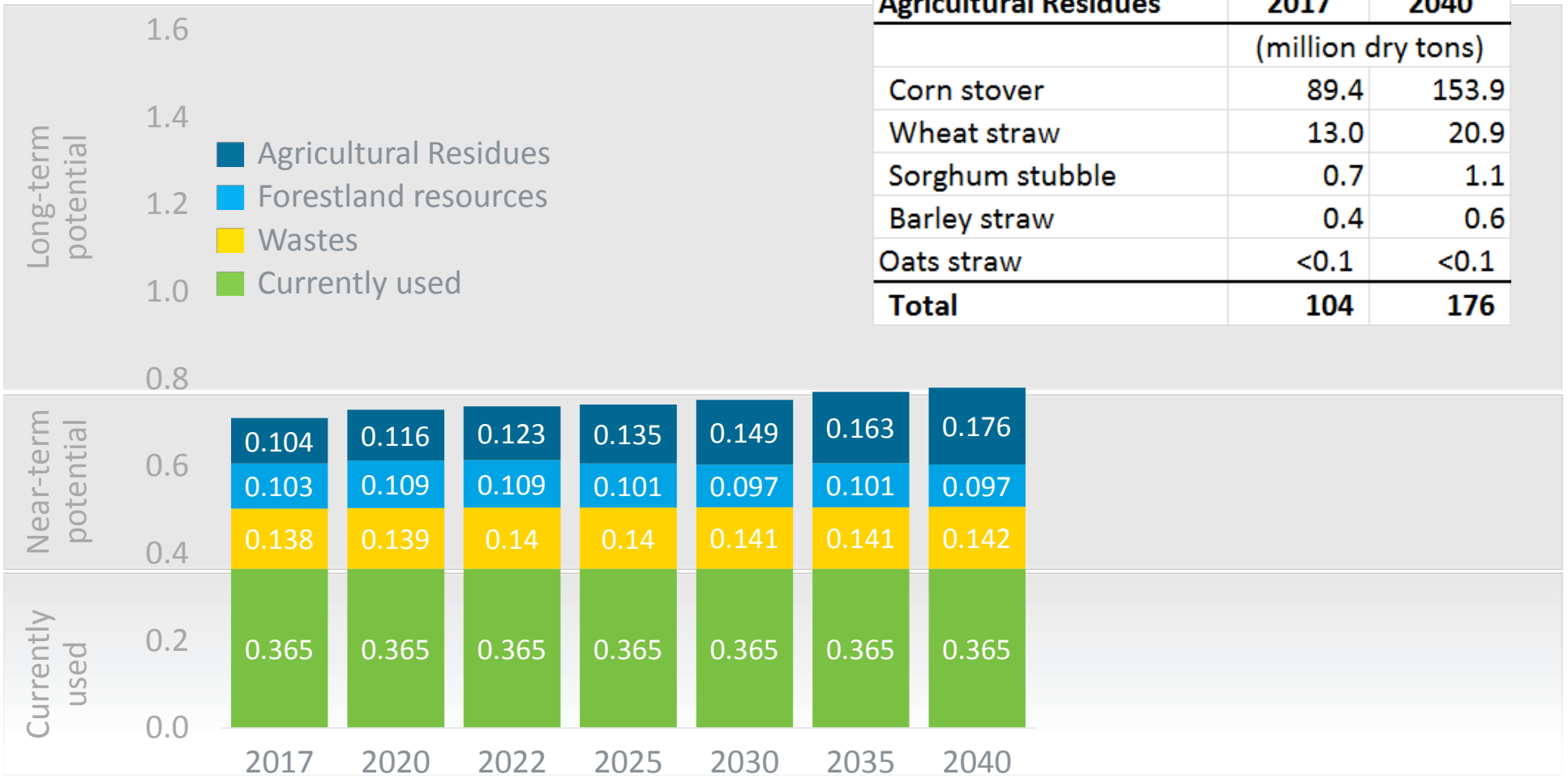
Billions of Dry Tons per year



Forestland Resources	2017	2040
	(million dry tons)	
Whole trees, hardwood	39.0	24.9
Whole trees, softwood	28.1	33.4
Other forest residue	12.2	13.0
Residues, hardwood	6.9	8.0
Residues, softwood	6.8	10.0
Residues, mixedwood	4.2	2.7
Whole trees, mixedwood	2.8	2.4
Other forest thinnings	2.6	2.6
Total	**103**	**97**

Current and Potential, Base-case, $60/dt

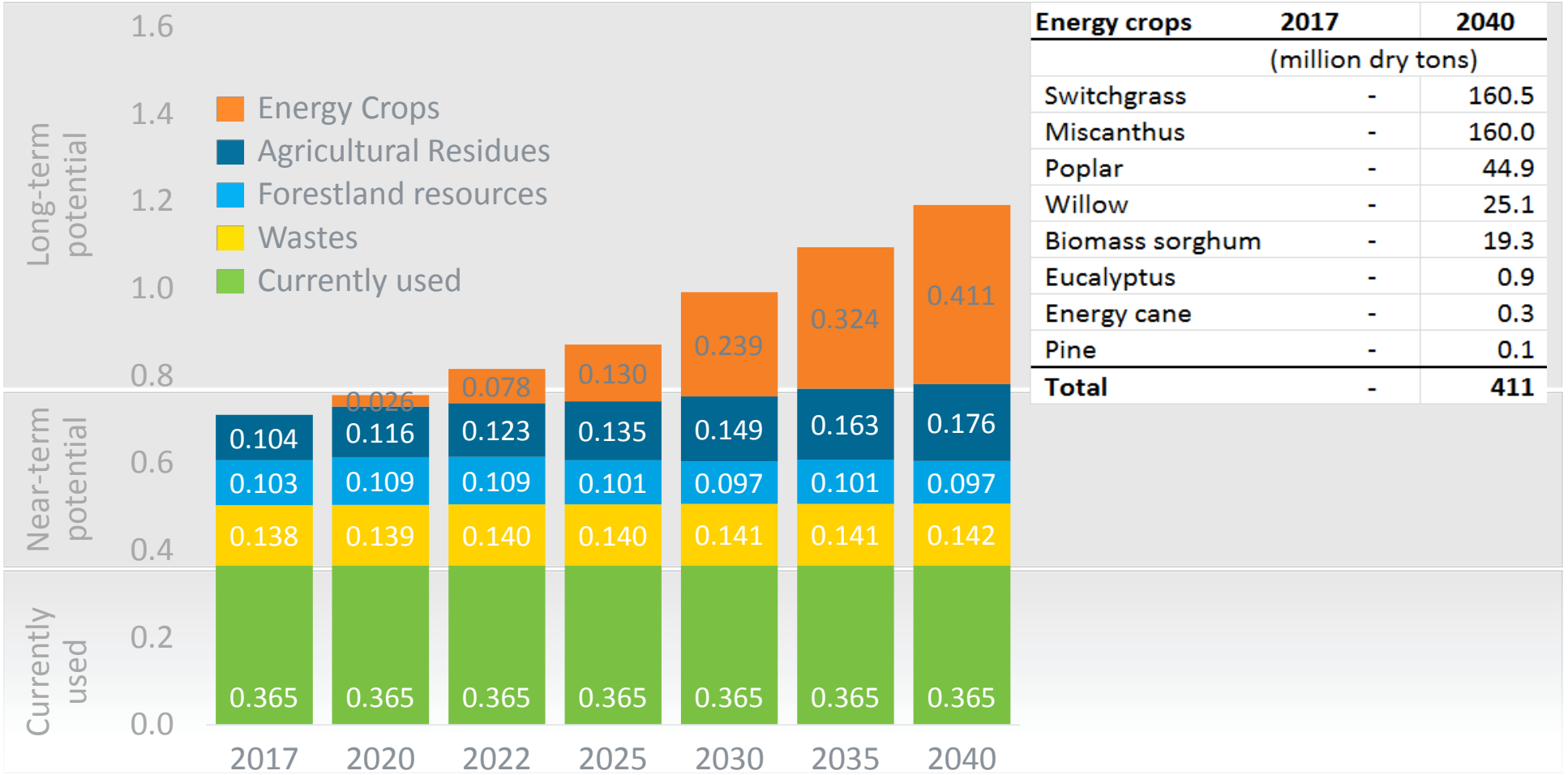
Billions of Dry Tons per year



Agricultural Residues	2017	2040
	(million dry tons)	
Corn stover	89.4	153.9
Wheat straw	13.0	20.9
Sorghum stubble	0.7	1.1
Barley straw	0.4	0.6
Oats straw	<0.1	<0.1
Total	**104**	**176**

Current and Potential, Base-case, $60/dt

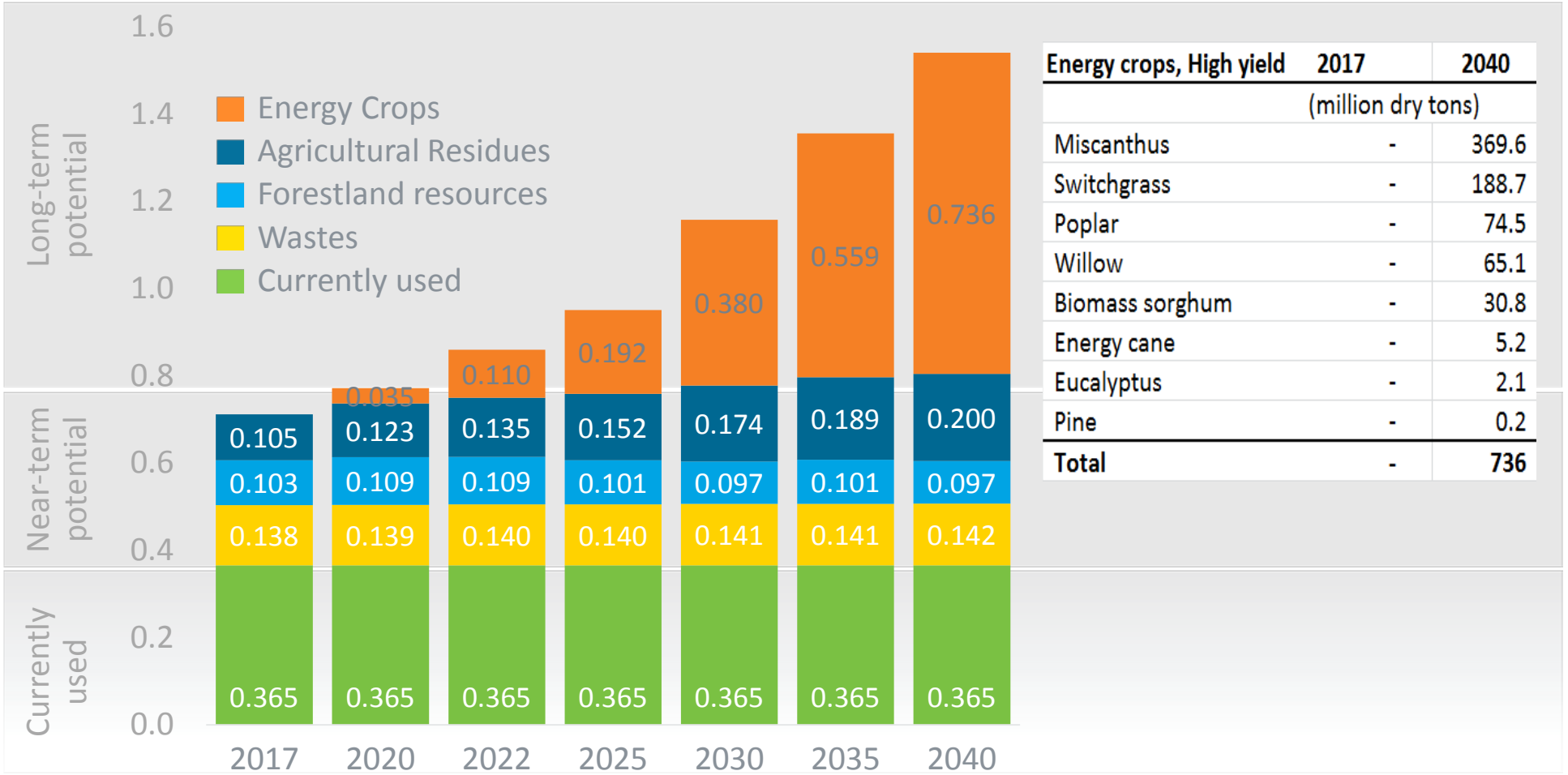
Billions of Dry Tons per year



Energy crops	2017	2040
	(million dry tons)	
Switchgrass	-	160.5
Miscanthus	-	160.0
Poplar	-	44.9
Willow	-	25.1
Biomass sorghum	-	19.3
Eucalyptus	-	0.9
Energy cane	-	0.3
Pine	-	0.1
Total	-	**411**

Current and Potential, High-yield, $60/dt

Billions of Dry Tons per year



Energy crops, High yield	2017	2040
	(million dry tons)	
Miscanthus	-	369.6
Switchgrass	-	188.7
Poplar	-	74.5
Willow	-	65.1
Biomass sorghum	-	30.8
Energy cane	-	5.2
Eucalyptus	-	2.1
Pine	-	0.2
Total	-	**736**

Feedstock[a] Availability Scenarios

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Price per dry ton[b]	Near term	Long term Base case	Long term High yield
Roadside at ≤ $60	310	679	985
Delivered ≤ $84	217	467	825
Delivered ≤ $100	217	564	825
Unused[c]	93	114	160

[A] Includes agricultural (biomass sorghum, corn stover, miscanthus, switchgrass, and yard trimmings) and woody (whole trees, logging residues, woody portions of C&D and MSW, and woody energy crops) feedstocks.

[B] Average costs used

[C] Unused resources are those delivered at greater than $100 per ton, lost along the supply chain, or part of the overcontracting buffer included in the near term systems to mitigate supply risk.

Interactive Resources

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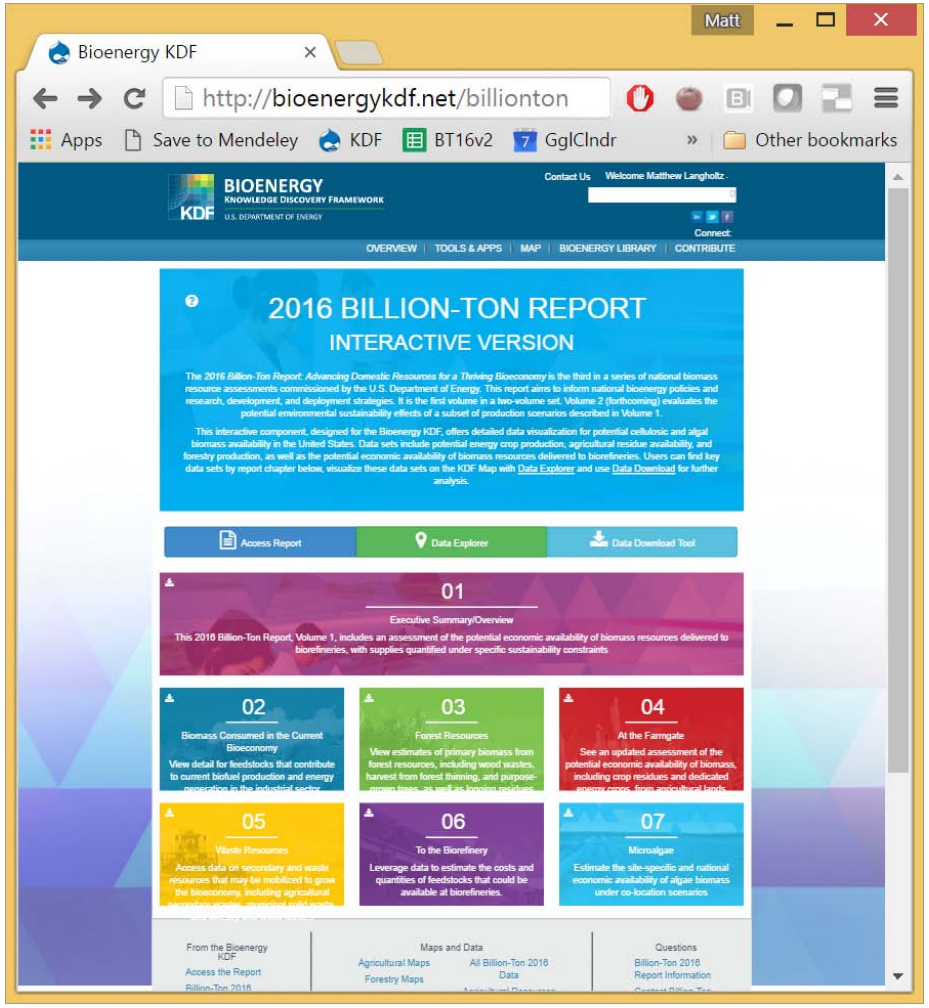
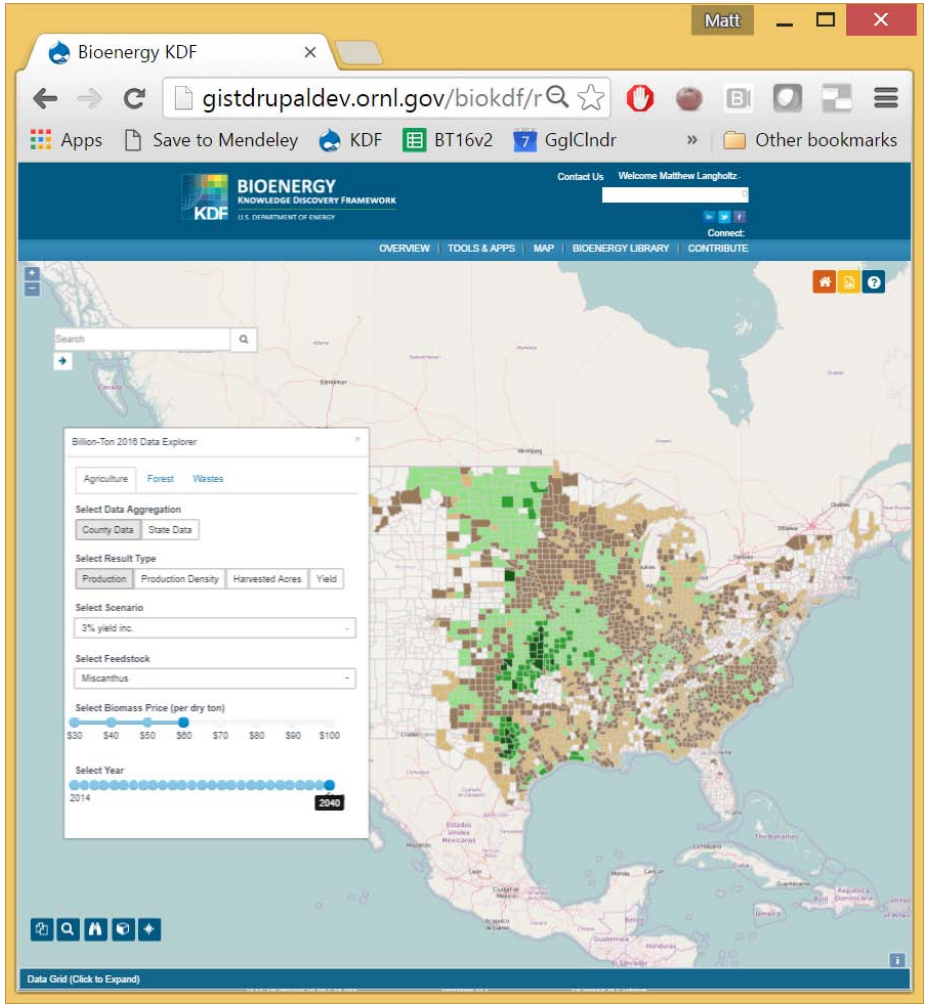
http://bioenergykdf.net/billionton





Volume 1 Key Conclusions

- Still have the potential for more than a billion tons of biomass available as early as 2030, and that continues to increase through 2040
  - 1-1.2 billion tons in 2030 and 1.2-1.5 billion tons in 2040
  - Projection based on $60/dt
  - Equivalent to 50-60 billion gallons of gasoline in 2030 at 50 gge/ton (conservative estimate as target is 87 gge/ton in 2017)
- Accounting for delivery to biorefinery lowers potential
  - 67-83% of potential biomass can be produced and delivered to biorefinery at less than $84/dt (about $1 of the $3 per gge target)
- Land to energy crops
  - Up to 64 million acres in 2040 for base case
  - Up to 88 million acres in 2040 for the high scenario
- Forest resources are regionally specific, and subject to macroeconomic and local market forces
- Algae has substantial potential, but prices will need to decrease for that potential to be realized

Thank You

For questions, please contact Mark Elless at

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or

Visit the KDF at

http://bioenergykdf.net/billionton

Summary of Market Priced Potential Resources at $60/dt

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Feedstock	2017	2022	2030	2040
	Million dry tons			
Base-case scenario				
Forestry resources currently used	171	171	171	171
Agricultural resources currently used	157	157	157	157
Waste resources currently used	30	30	30	30
Forestry resource potential	88	93	81	82
Agricultural residues and waste resources potentially available	261	285	314	344
Energy crops	0	78	239	411
Algae				47*
Total	707	814	993	1242
High-yield scenario				
Forestry resources currently used	171	171	171	171
Agricultural resources currently used	157	157	157	157
Waste resources currently used	30	30	30	30
Forestry resource potential	79	83	72	61
Agricultural residues and waste resources potentially available	262	297	339	368
Energy crops	0	110	380	736
Algae				47*
Total	700	848	1150	1570

$60/dt is based on supply curve and does not account for delivery

*Estimates of algae availability range from 23- 110 million dry tons at costs from $490 - $2889, as shown in Table ES.3

Key Assumptions/Issues

- Biomass potential is a function of cost-to-roadside of supply locations, year, and scenario (does not include use).
- Excludes policy (RFS starches/biodiesel included in current uses).
- Models meet food, forage, feed, and fiber (even export) requirements to 2040. (USDA Long-Term Outlook and Resources Planning Act).
- New feedstocks added, e.g., algae, miscanthus, energy cane, and eucalyptus.
- Agriculture and forest lands are held constant but allocation changes occur in agriculture. Conservation Reserve Program lands are excluded.
- Underlying assumptions are intended to be conservative and have built-in "sustainability" (environmental quality) considerations.
  - Sustainability categories:
    - Soil quality
    - Water quality
    - Water quantity
    - Greenhouse gas emissions
    - Biodiversity

Combined Potential Supplies from Forestry, Wastes, and Agricultural Resources, Base Case, 2040*

*Combined potential = 873 million dry tons per year including algae, biosolids, trap grease, food processing waste, and utility tree trimming not shown.