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

Biomass Econ 101: Measuring the Technological Improvements on Feedstocks Costs

Bioenergy 2015: A Changing Market for Biofuels and Bioproducts

June 23, 2015

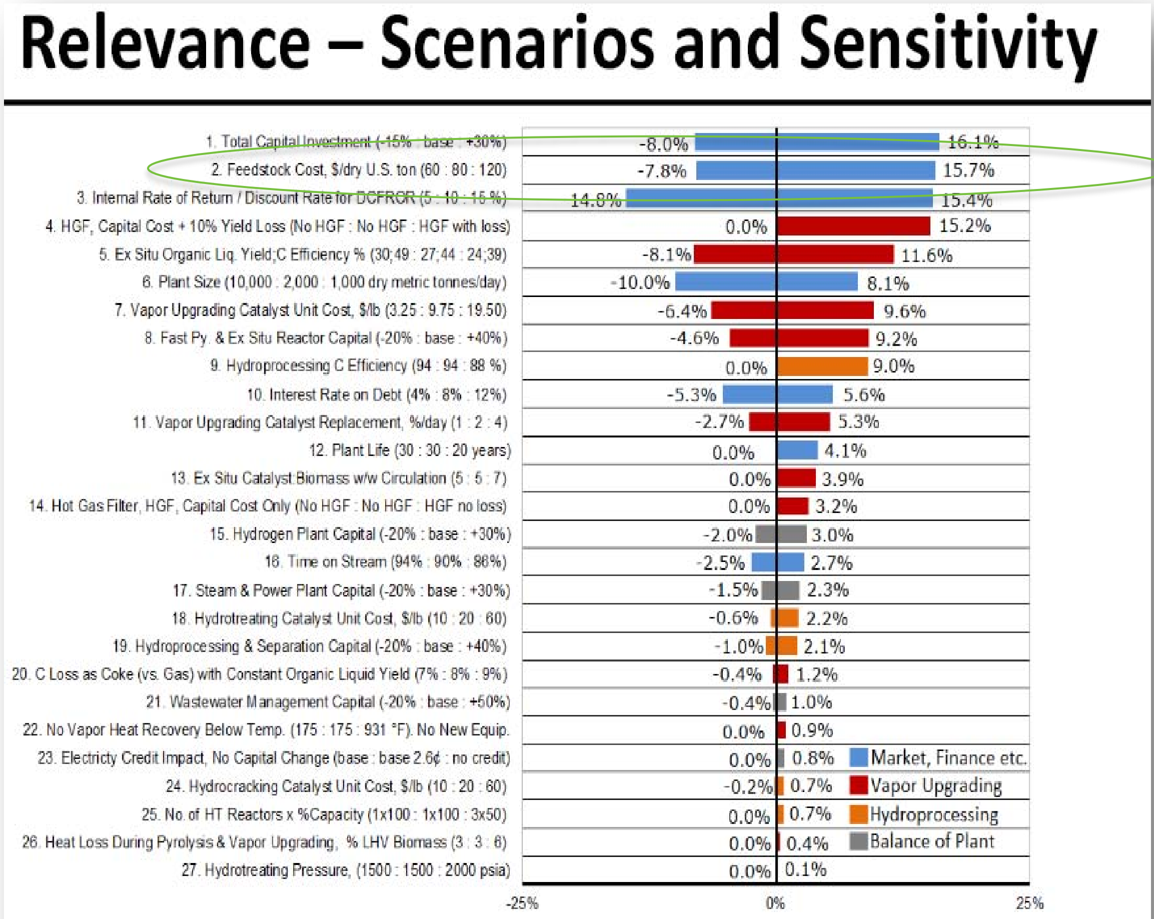
Laurence Eaton
Research Economist
ORNL M&O Subcontractor to DOE/BETO

Overview

- Why feedstocks?
- Review results of BT2
- Supply curve fundamentals
- Cost reductions through technological improvements
  - Economics of switchgrass
- Preview of BT16

MFSP Sensitivity of Biomass Conversion

- Feedstock cost is 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)



Example of sensitivity studies for *ex situ* case

http://www.energy.gov/sites/prod/files/2015/04/f21/thermochemical_conversion_dutta_210302.pdf

Cost variability = RISK

BT2 Table ES-1: Current and Potentially Available Feedstocks

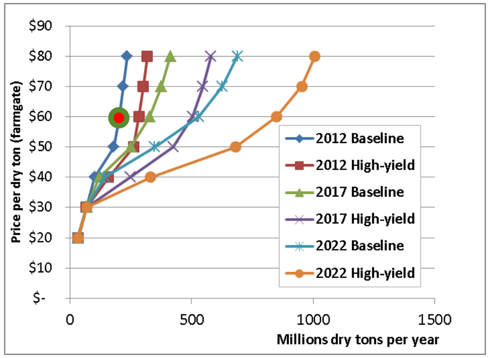
Feedstock	2012	2017	2022	2030
		Million dry tons		
Baseline scenario				
Forest resources currently used	129	182	210	226
Forest biomass & waste resource potential	97	98	100	102
Agricultural resources currently used	85	103	103	103
Agricultural biomass & waste resource potential	162	192	221	265
Energy crops[a]	0	101	282	400
Total currently used	**214**	**284**	**312**	**328**
Total potential resources	**258**	**392**	**602**	**767**
Total – baseline	**473**	**676**	**914**	**1094**
High-yield scenario (2%–4%)				
Forest resources currently used	129	182	210	226
Forest biomass & waste resource potential	97	98	100	102
Agricultural resources currently used	85	103	103	103
Agricultural biomass & waste resource potential[b]	244	310	346	404
Energy crops	0	139–180	410–564	540–799
Total currently used	**214**	**284**	**312**	**328**
Total potential	**340**	**547–588**	**855–1009**	**1046–1305**
Total high-yield (2-4%)	**555**	**831–872**	**1168–1322**	**1374–1633**

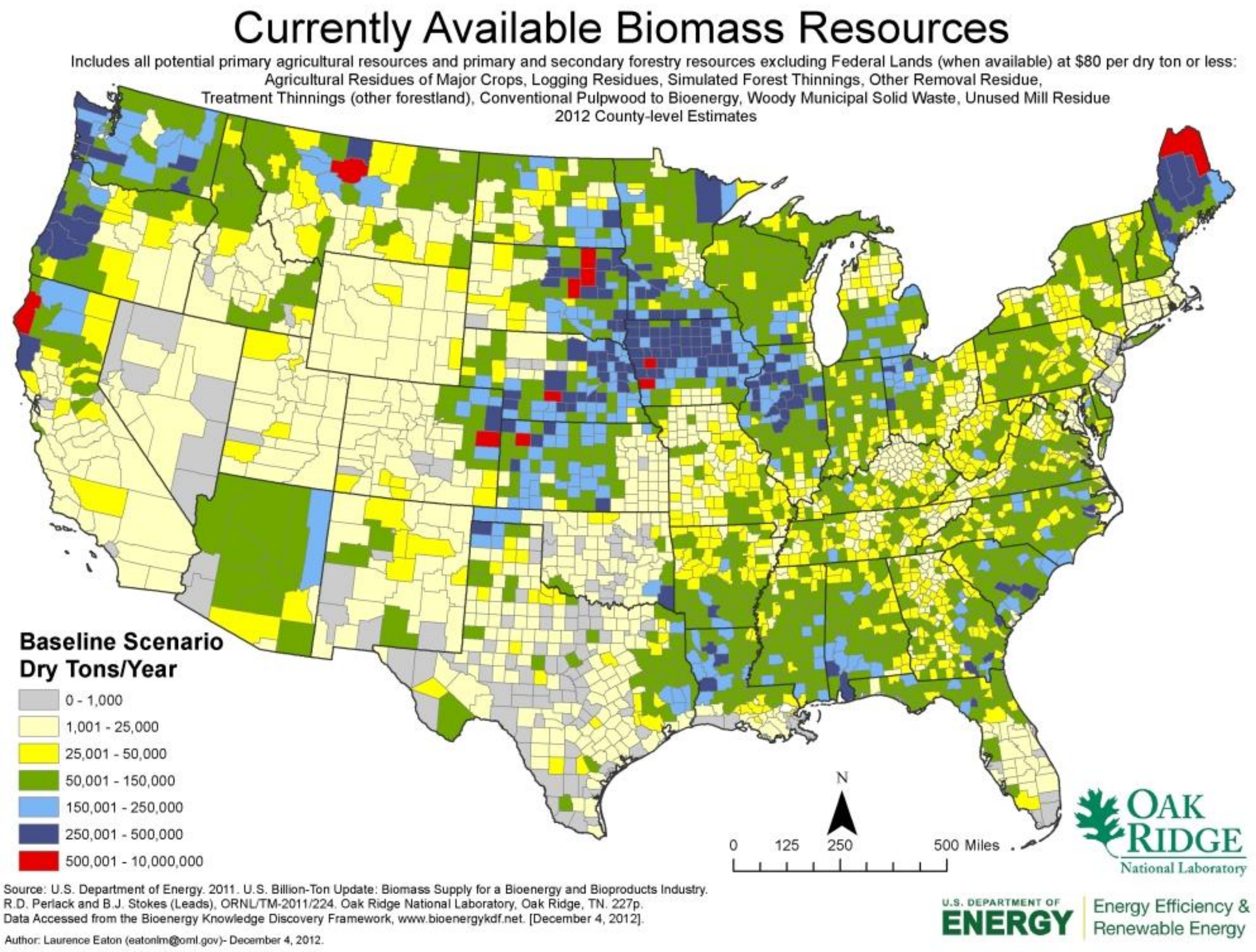
Near-term Potential

www.bioenergykdf.net

- 2012
- Baseline scenario
- $60 dry ton^{-1}

201 x 10^6 dt



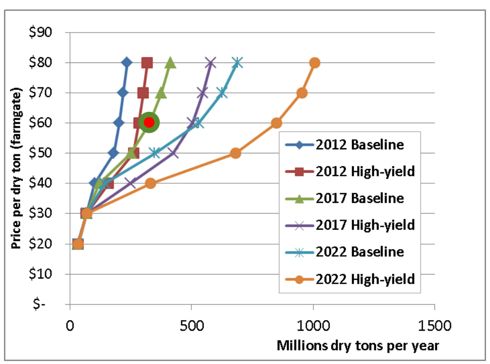


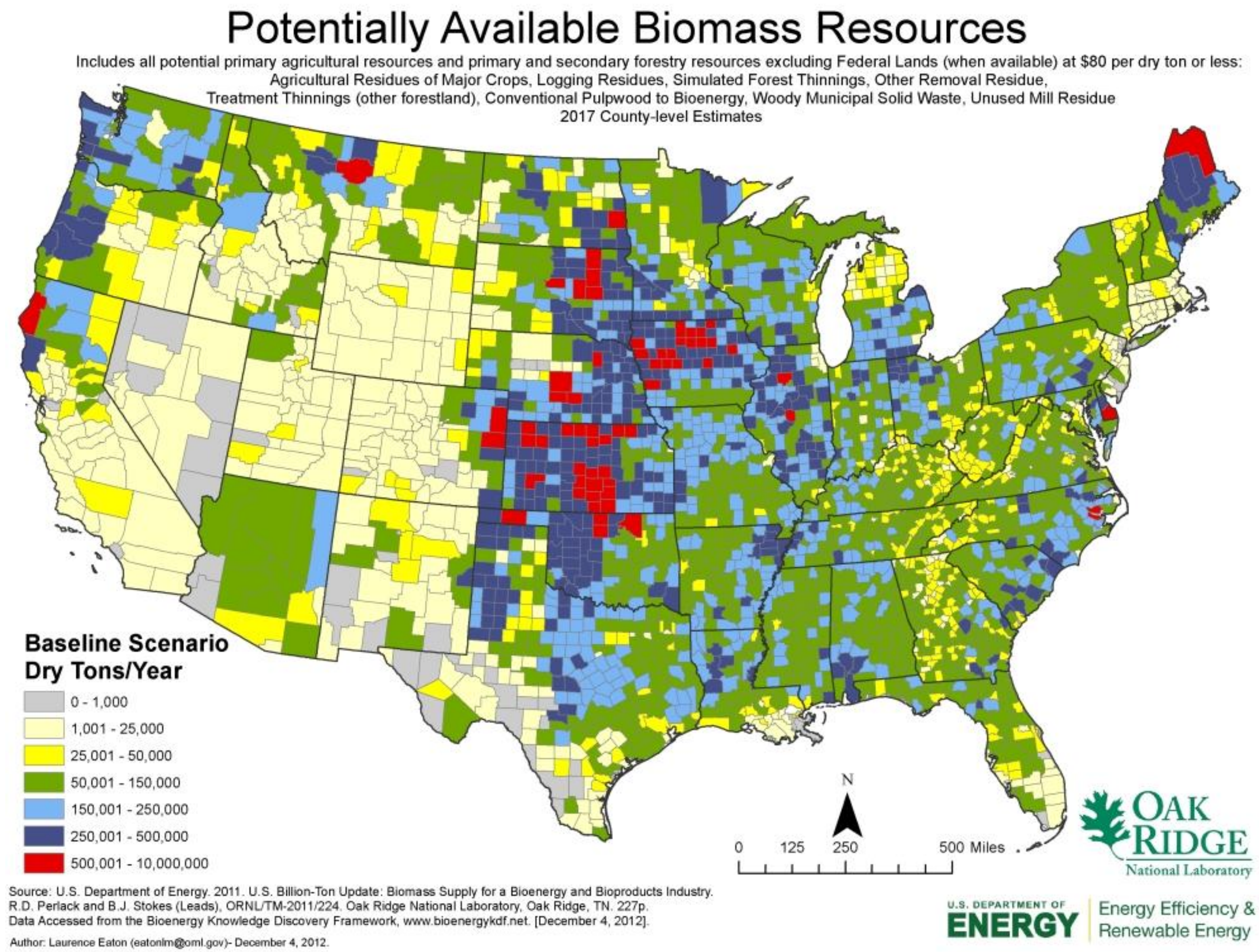
Billion-ton Results

www.bioenergykdf.net

- **2017**
- **Baseline scenario**
- **$60 dry ton^{-1}**

327 x 10^6 dt





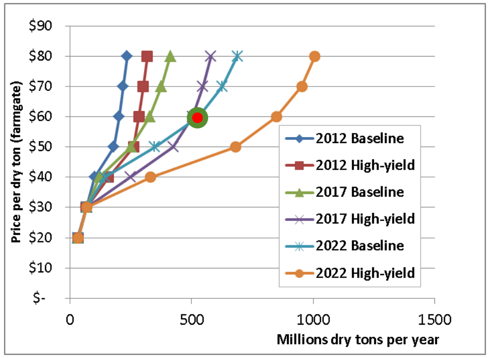
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

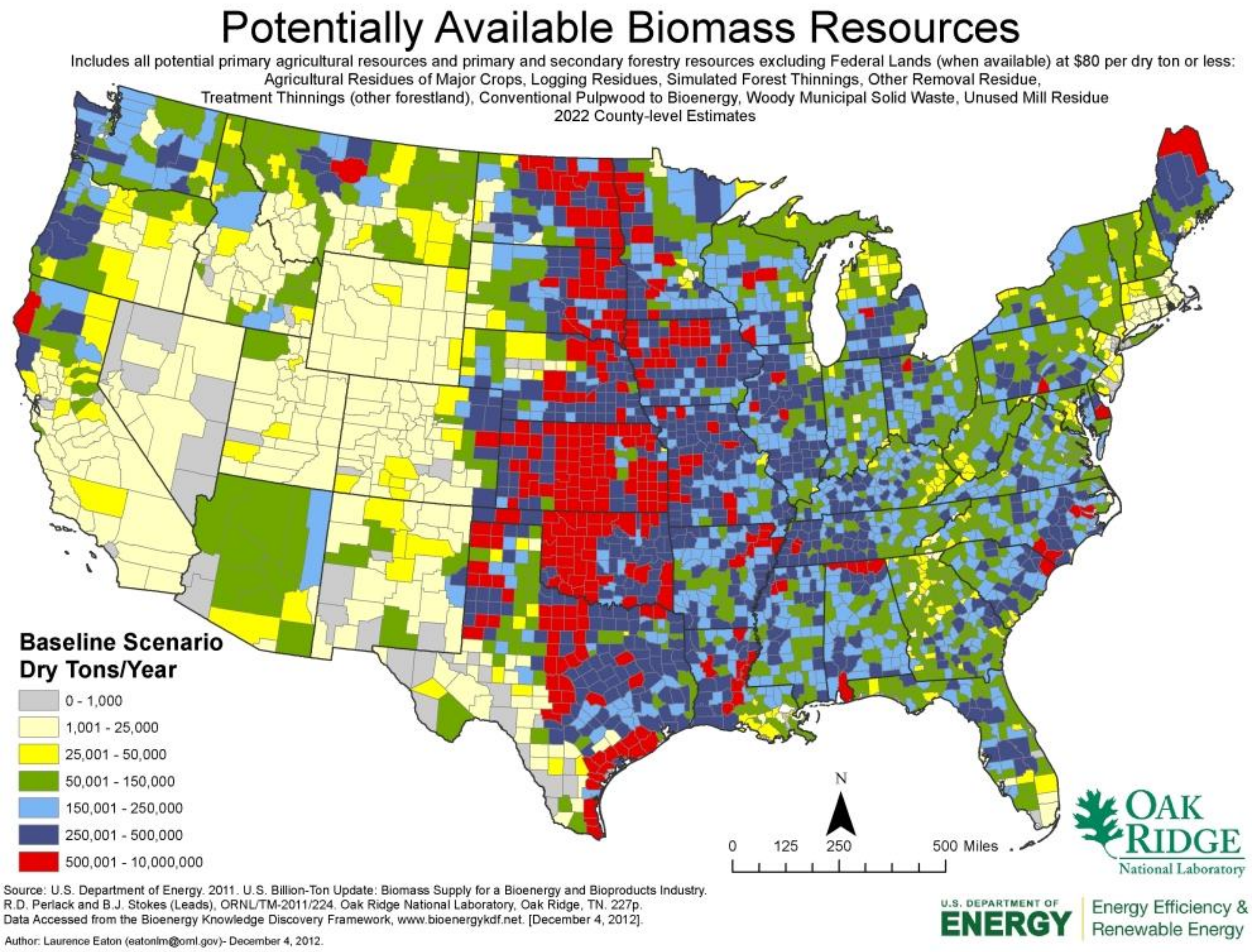
Billion-ton Results

www.bioenergykdf.net

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

529 x 10^6 dt



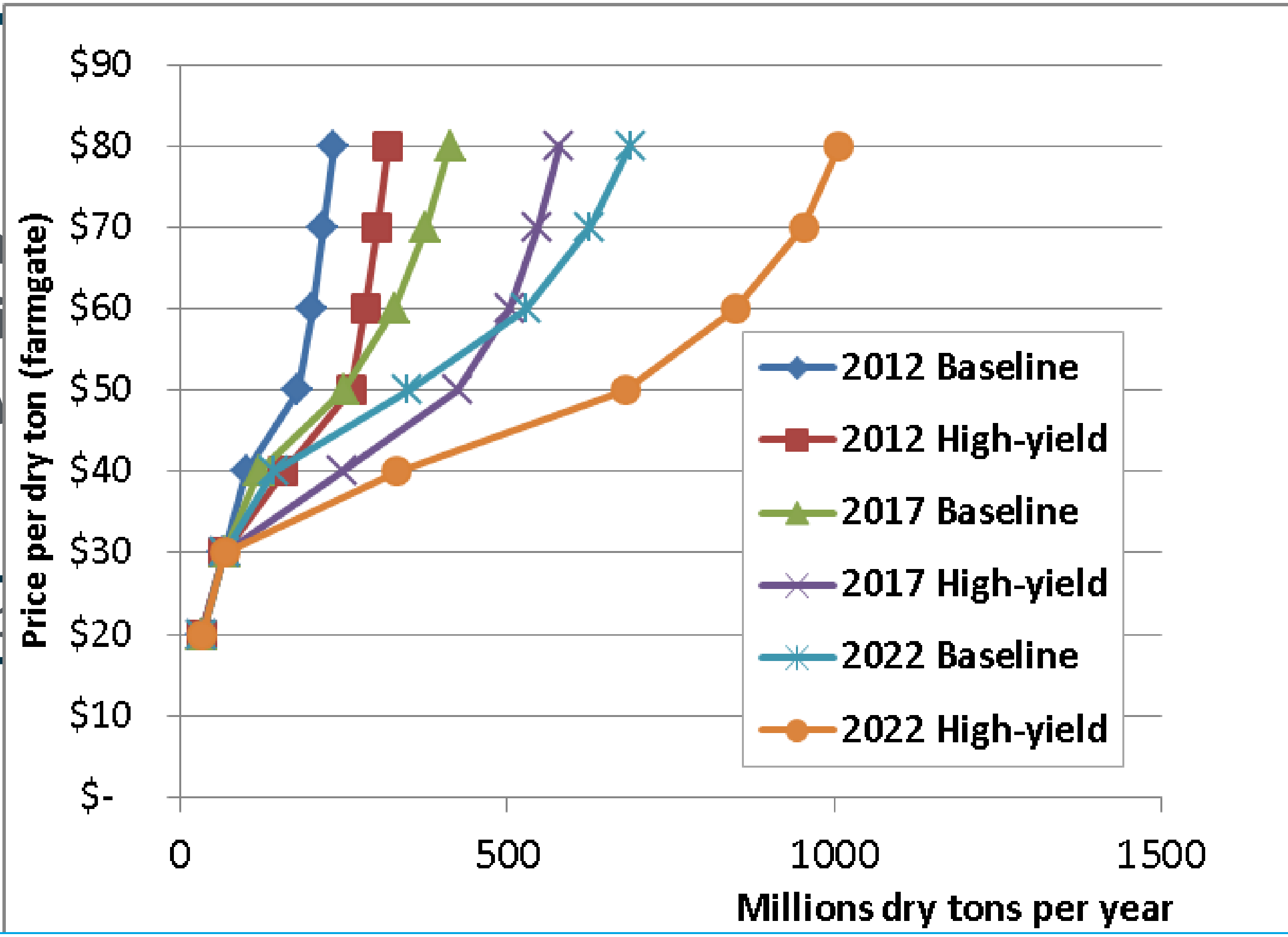


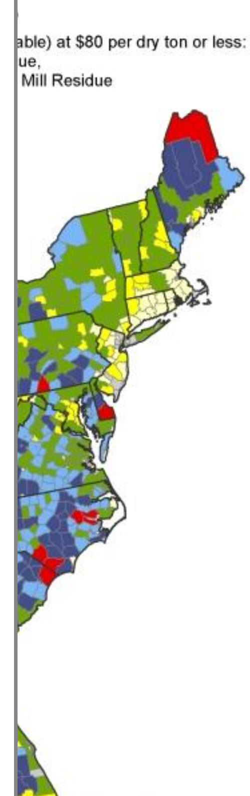
Billion-ton Results

www.bioenergykdf.net

- 2022
- Baselin
  scenari
- $60 dry

529 x





Supply = f (# producers, input costs, machinery, expected yield and technological improvements, etc)

GE
ratory
cy &
ergy
&
y

Factors to improve economics of perennial crops

- Improved yield
  - **Increased establishment success, quicker stand maturity**
  - **Better varieties for site conditions**
  - Reduced yield variability between dry/wet years
- Reduced need for herbicides and nutrients
- **Reduced harvest costs (DOE High-tonnage Logistics Project and Project 1.2.3.1 Supply Chain Analysis)**

Switchgrass production example

- Reference Case
  - 10-year rotation length
  - Yield at 33% of maturity in year 1, 66% in year 2, and 100% in years 3-10
  - Discount rate 6.5%
  - Switchgrass follows soybeans and is established using no-till methods
  - Costs include establishment, maintenance, and harvest
- Improved Cases

  1) Yield at 50% of maturity in year 1, 75% in year 2, and 100% in years 3-10

  2) Reduced harvest and on-farm transport cost of $4/dt

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

Example Scenario of Cost Impacts of Switchgrass Improvements

Scenario	Average Cost of Production	Cost Reduction
Reference*	$ 55.06	
1) Increased Maturity	$ 53.06	-3.6%
2) Reduced Harvest Cost**	$ 52.75	-4.2%
1+2) Increased Maturity and Improved Harvest	$ 50.66	-8.0%

* Production budgets include land rental rate of $77/acre for improved pasture in Iowa; Mature yield of 6 dry tons/acre; Cost assumptions from Iowa State “Estimated Cost of Establishment and Production of ‘Liberty’ Switchgrass,” May 2015 (File A1-29)

** Demonstrated $4/dry ton by TennEra High-tonnage Logistics Project validated by ORNL 1.2.3.1 Supply Chain Analysis Project

Example Scenario of Cost Impacts of Switchgrass Improvements

Scenario	Average Cost of Production	Cost Reduction
Reference*	$ 55.06	
1) Increased Maturity	$ 53.06	-3.6%
2) Reduced Harvest Cost**	$ 52.75	-4.2%
1+2) Increased Maturity and Improved Harvest	$ 50.66	-8.0%
1 + 2 + Increased Yield (7 dry tons/acre)	$ 42.81	-22.2%

* Production budgets include land rental rate of $77/acre for improved pasture in Iowa; Mature yield of 6 dry tons/acre; Cost assumptions from Iowa State "Estimated Cost of Establishment and Production of 'Liberty' Switchgrass," May 2015 (File A1-29)

** Demonstrated $4/dry ton by TennEra High-tonnage Logistics Project validated by ORNL 1.2.3.1 Supply Chain Analysis Project

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.

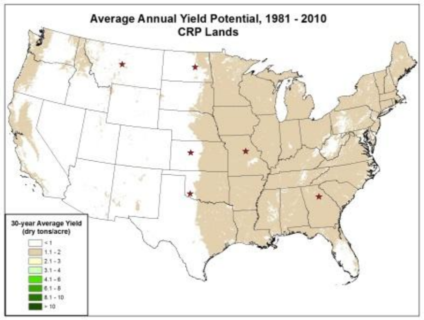
SunGrant INITIATIVE

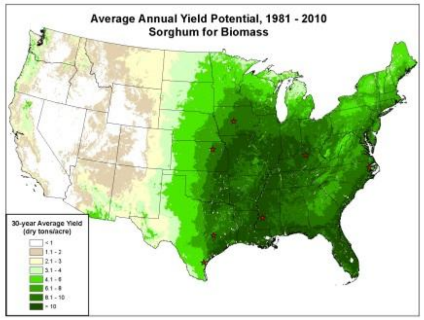
OAK RIDGE National Laboratory

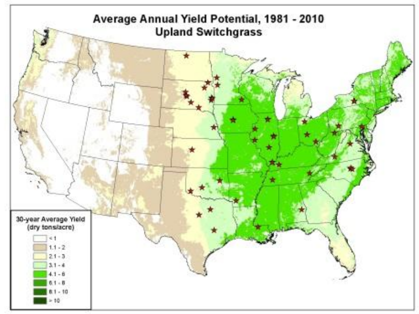
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

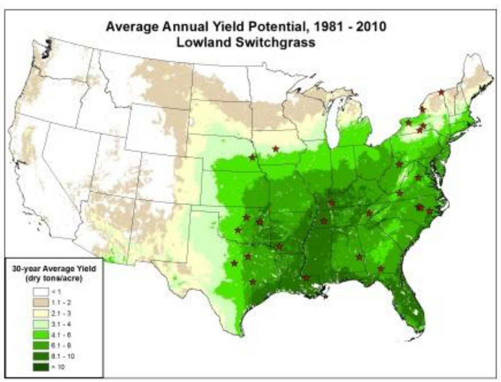
Enhanced Energy Crop Potential Yield

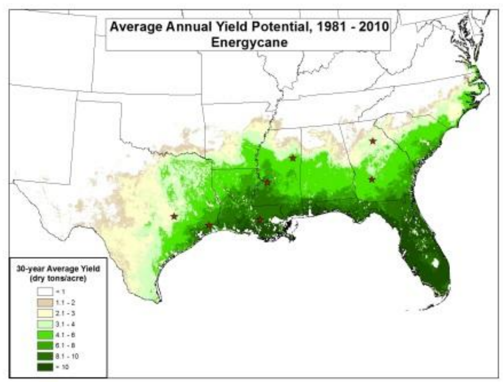
Herbaceous Energy Crops



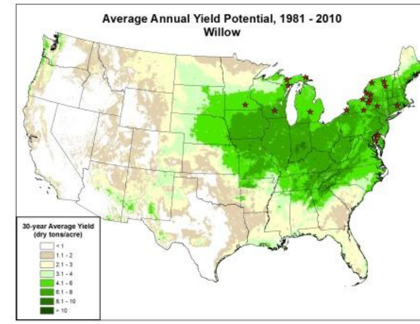


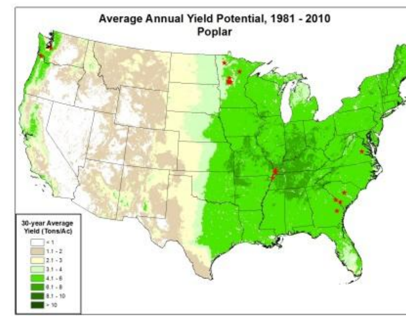


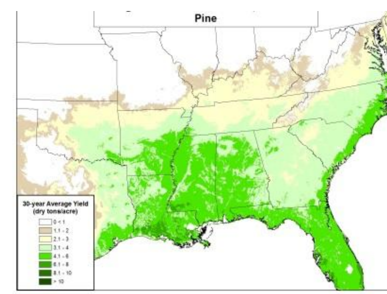




Woody Crops







Manuscript in preparation by SGI Field Trial and Resource Assessment Teams

Credit: Oregon State University PRISM Climate Group

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

Genera Energy/UT-Knoxville Bioenergy Field Day, 2013. Credit: Laurence Eaton

Photo Credit: Sapphire Energy (http://zebrapartners.net/sapphiremedia/Green-Crude-Farm-2013.html)

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

2005 BTS	2011 Update	2016 Update
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 and 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; 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 will feature **robust analysis of environmental sustainability**

Collaborators

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

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

Thank you!

Laurence Eaton

laurence.eaton@ee.doe.gov

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

References

- U.S. Department of Energy and U.S. Department of Agriculture. 2005. **Biomass as a feedstock for a bioenergy and bioproducts industry: The technical feasibility of a billion-ton annual supply.** DOE/GO-102005-2135 ORNL/TM-2005/66.
- U.S. Department of Energy. 2011. **U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry**. R.D. Perlack and B.J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN. 227p.
- U.S. Department of Energy. 2015. **Multi-year Program Plan.**