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Billion Ton 2016 Preview*

Biomass R&D Board Technical Advisory Committee

August 27, 2015

***Based on May 27, 2015 BETO Webinar**

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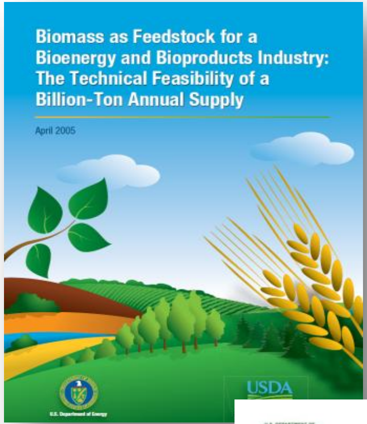
History and Accomplishments

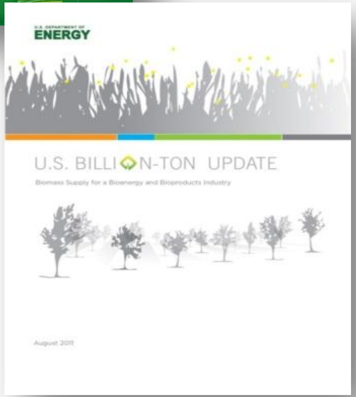


<u>Billion-Ton Study (BTS), 2005</u>

- **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**

<u>Billion-Ton Update (BT2), 2011</u>

- **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.**



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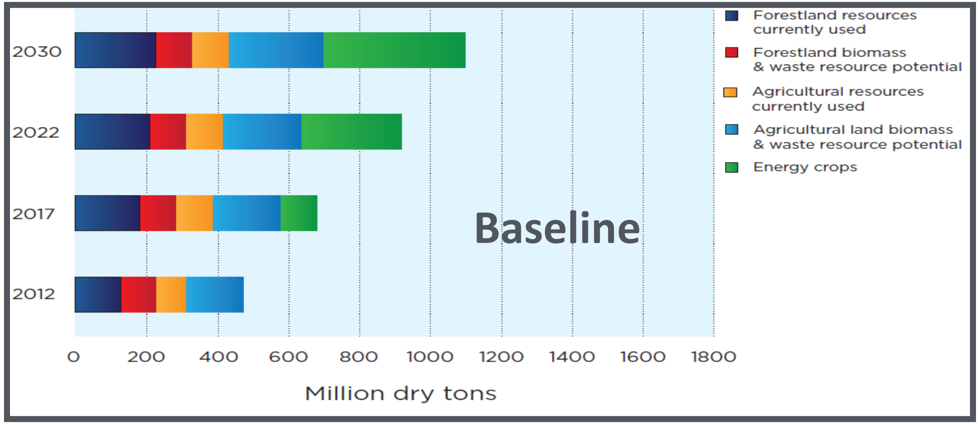
Preamble to Billion-ton Update

- 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

U.S. Billion-Ton Update: Findings

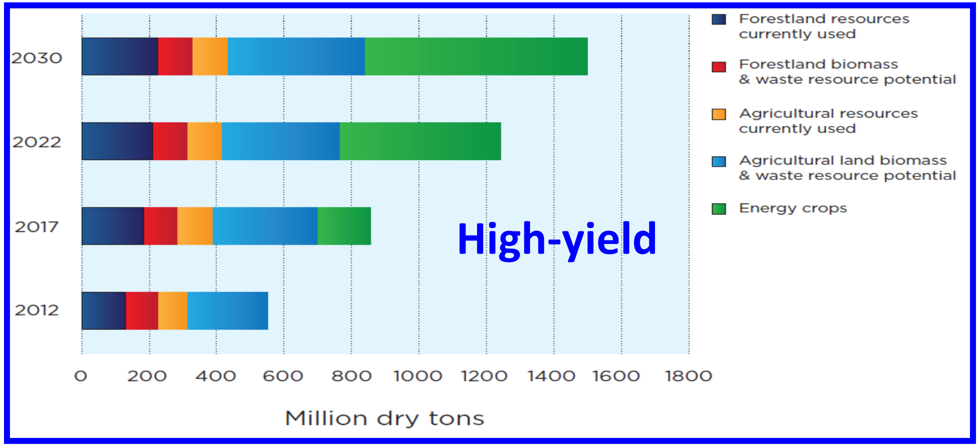
Baseline scenario

- 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.

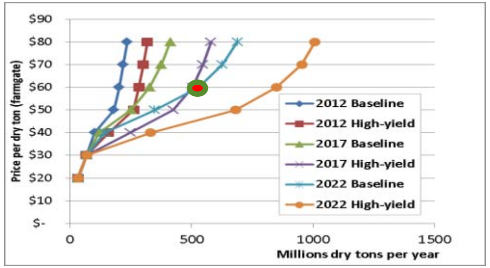


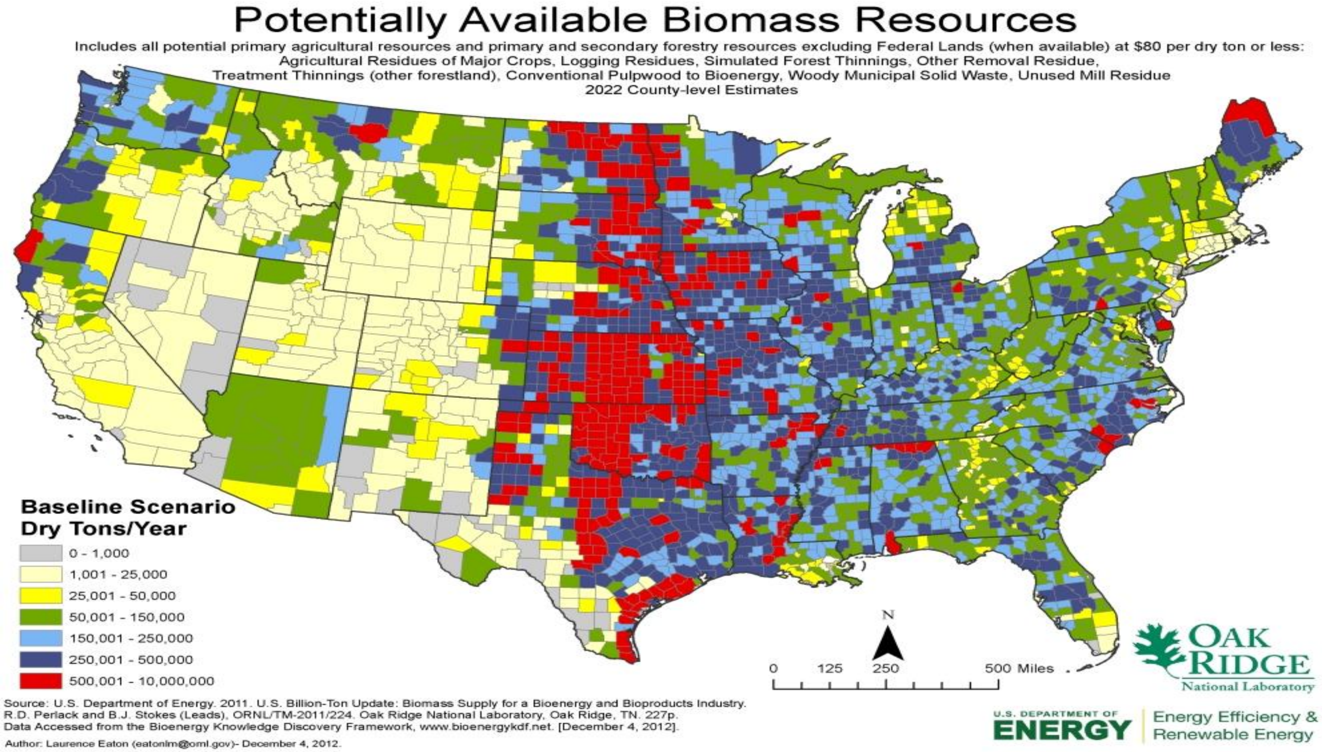
Billion-ton Results

www.bioenergykdf.net

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

529 x 10^6 dt

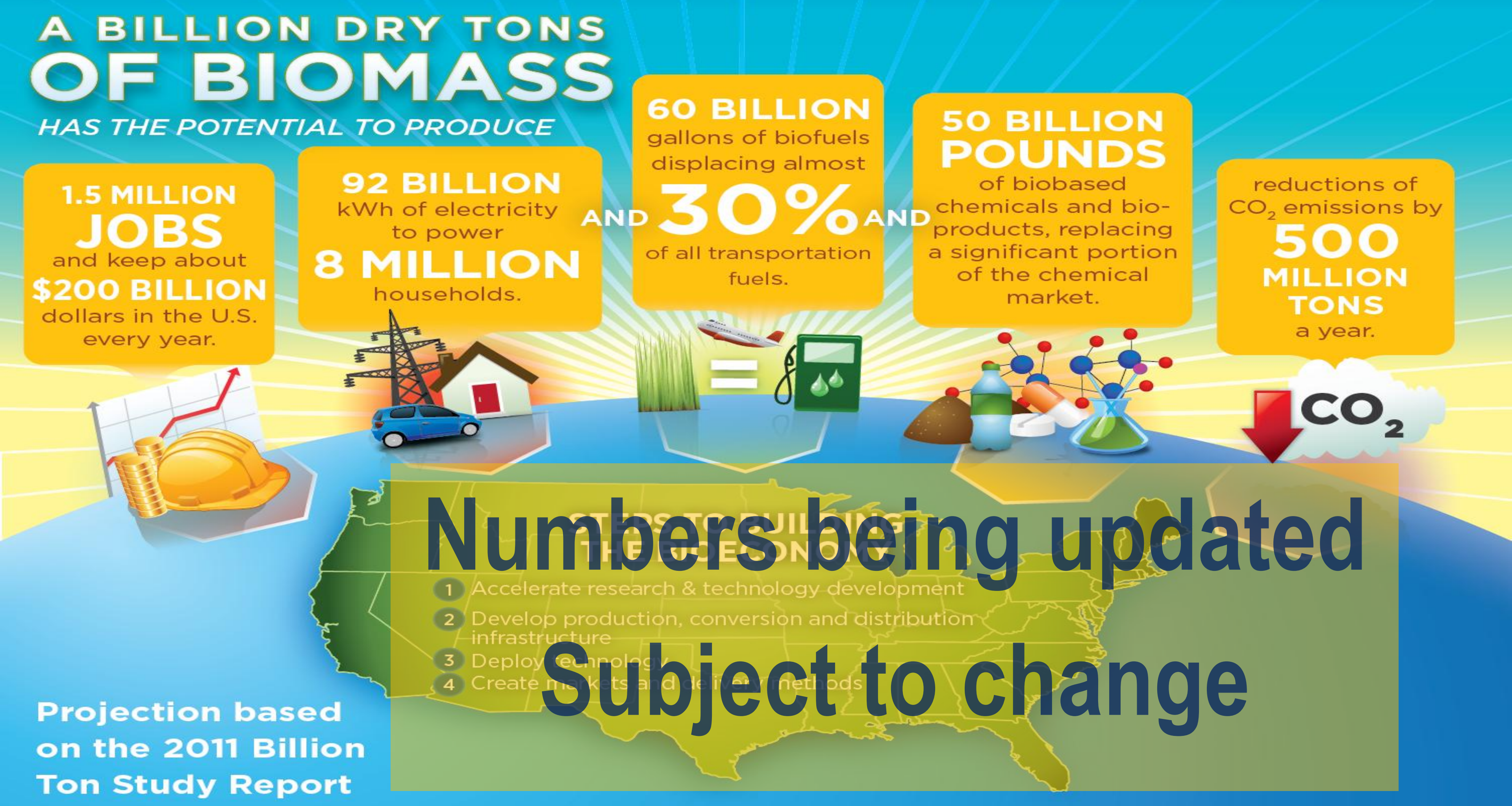




One billion tons of biomass would fill the **Dallas Cowboys AT&T Stadium 1600 times.**

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

Dallas Cowboys AT&T Stadium – Arlington, Texas



Numbers being updated
Subject to change

Dave Danielson, Advanced Bioeconomy Leadership Forum, March 11, 2015. Washington, DC.

Global Biomass Potential

Region	Energy Crops (Million Acres)	Supply Potential (Billion Dry Tons)
Europe	62-222	0.4-1.5
USA 2005 BTS	74	1.1
USA 2011 BTS	63	1.4
Latin America	299	1.5
China & India	212	1.7
Australia	-	<4M

From Bauen et al., 2009. Timeframes are 2017-2030 and Table 6.4, Billion-ton Update.

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IEA Technology Roadmap *Biofuels for Transport* (2011)

- 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

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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)

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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**

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

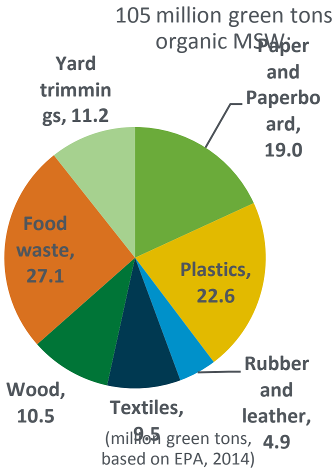
Additional feedstocks: Algae and MSW

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.



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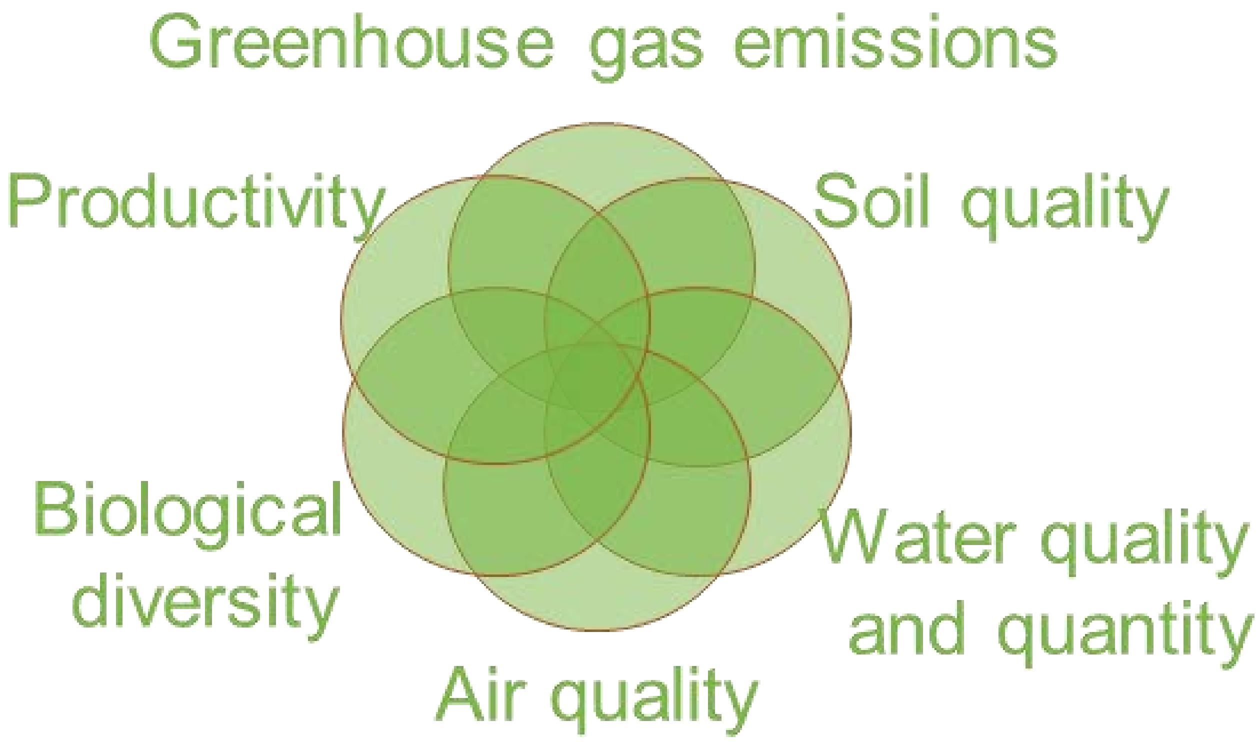
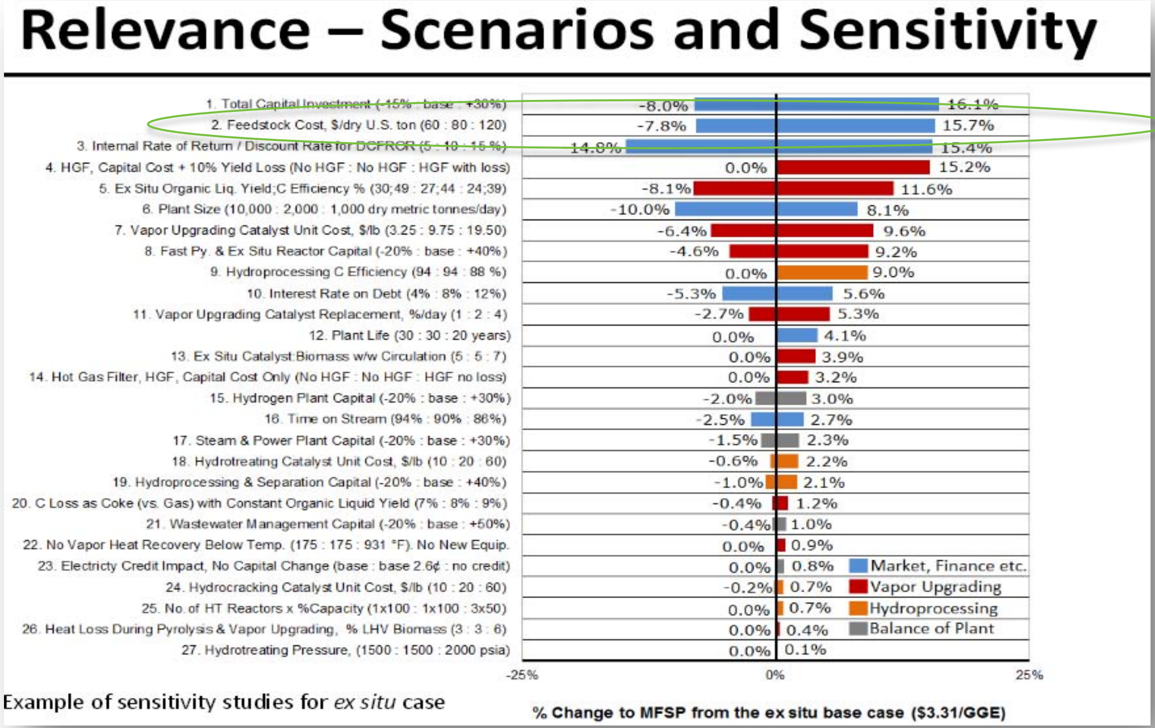
Integrating Sustainability Considerations into the Resource Analysis



Economics of Biomass and Conversion

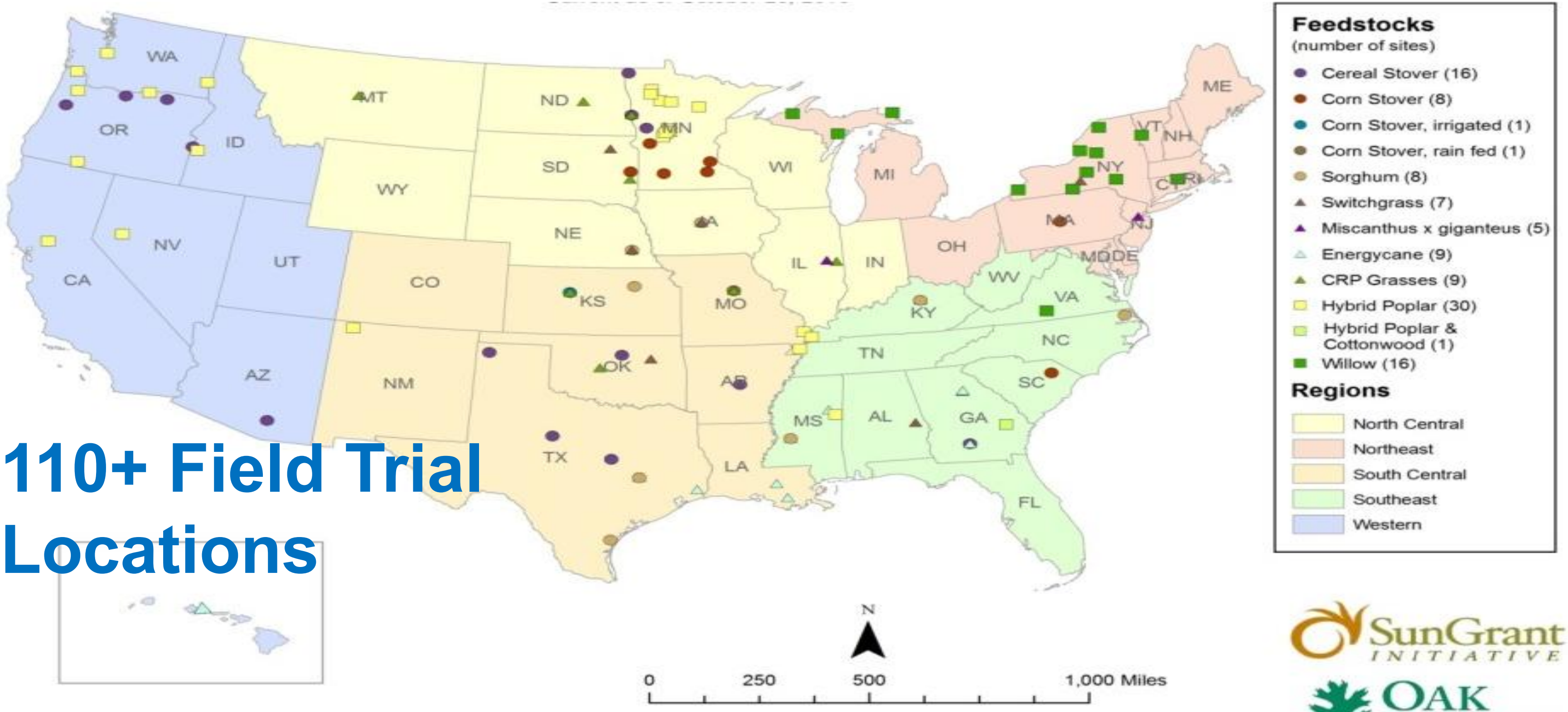
- Feedstock cost is 2nd largest source of cost variability in 2014 Thermochemical Minimum Fuel Selling Price (-7.8% to +15.7%)
- In Biochemical and Thermochemical process design cases (Technoeconomic Analysis), feedstocks costs consistently account for about 1/3 of Minimum Fuel Selling Price (MFSP)



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

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.

SunGrant Initiative

Oak Ridge National Laboratory

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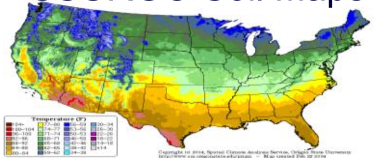
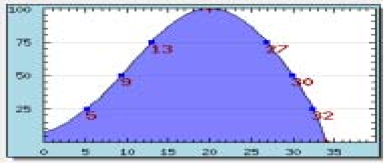
National Crop Yield and Variability Modeling

SSURGO Soil Maps

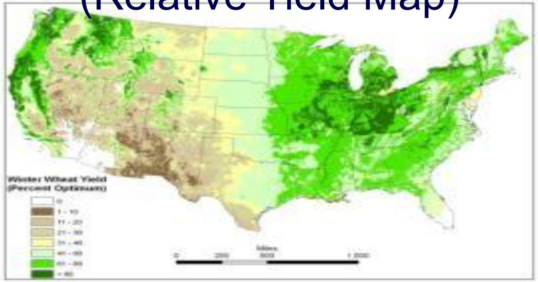


PRISM Climate Maps

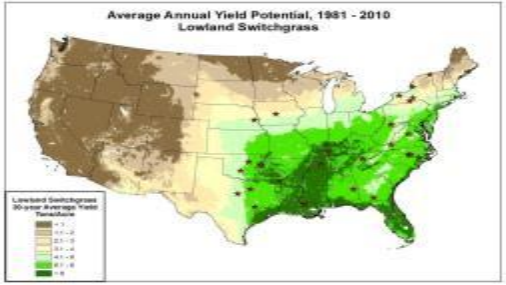


PRISM-EM Crop Suitability Model

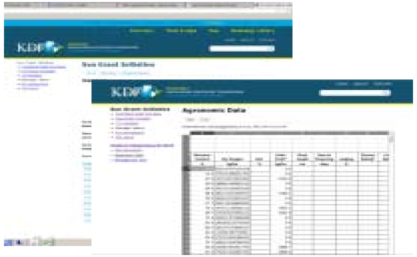
Percent of Maximum Yield (Relative Yield Map)



Biomass Yield



Interface with Crop Experts



KDF Field Trial Database

SunGrant INITIATIVE

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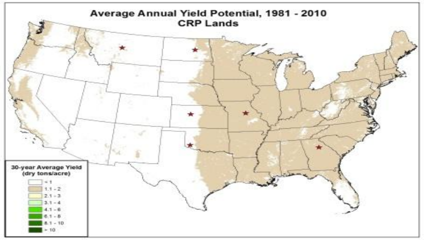
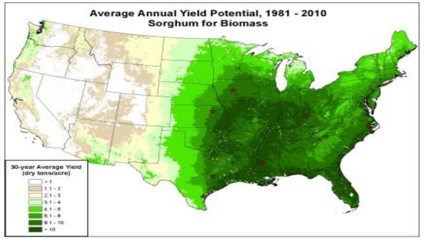
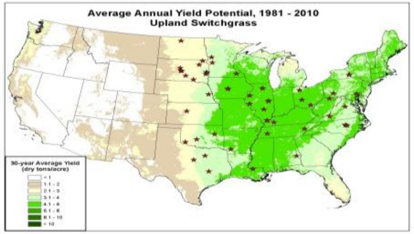
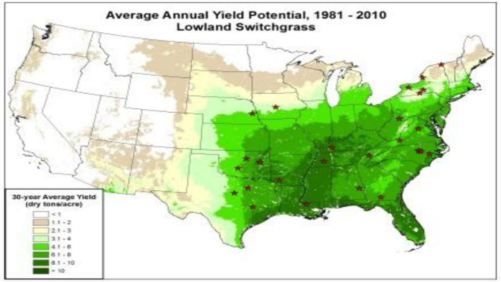
Enhanced Energy Crop Potential Yield

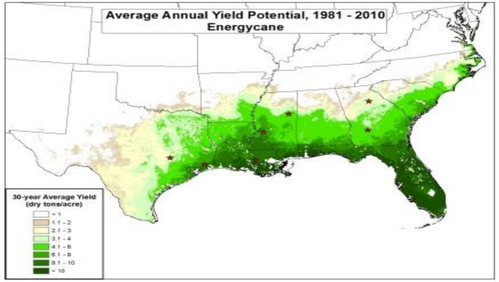
Herbaceous Energy Crops



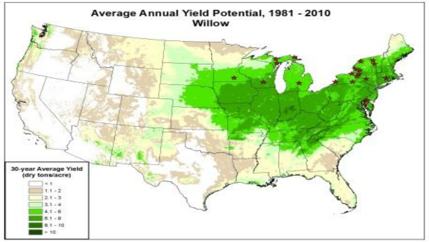


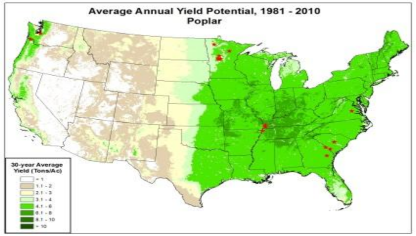


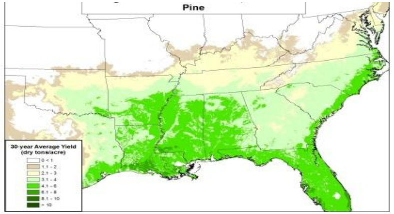




Woody Crops







Manuscript in preparation by SGI Field Trial and Resource Assessment Teams

Credit: Oregon State University PRISM Climate Group

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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

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