OVERVIEW

• 2005 Billion Ton Report recap
• Goals of the 2010 Update
• Key assumptions of methods of analysis
  – Agricultural Resources
  – Forest Resources
• Results
2005 Billion Ton Report

- Does the U.S. land base have the potential to produced a sustainable supply of biomass to displace 30% of current (2005) petroleum consumption?
- Identified >1.3 billion tons of feedstocks annually to support a bioenergy and bioproducts industry

Policy Environments of 2005 vs. 2010

- EISA (2007) mandates 36 billion gallons of ethanol by 2022
  - Maximum of 15 billion gallons of corn ethanol
  - Remaining 21 billion gallons to come from cellulosic and advanced sources
Goals of the Update

• To address potential biomass resource availability at target prices and high spatial resolution
• To improve upon the data, the methodology, and projections of 2005 Billion Ton Study
• To make the data and analysis transparent and available to others
• To address concerns and issues from the 2005 study

Key Differences Between the 2005 Billion Ton Study and the 2010 Billion Ton Update

<table>
<thead>
<tr>
<th>2005 Billion Ton Report</th>
<th>2010 Billion Ton Update</th>
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<tbody>
<tr>
<td>National estimates</td>
<td>County-level with aggregation to state, regional and national levels</td>
</tr>
<tr>
<td>No price or cost analyses</td>
<td>Supply curves by feedstock by county at farmgate/forest landing</td>
</tr>
<tr>
<td>Crop residue removal sustainability addressed from national perspective; erosion only</td>
<td>Crop residue removal sustainability modeled at soils level; erosion &amp; soil carbon</td>
</tr>
<tr>
<td>No explicit land use change modeling</td>
<td>Land use change modeled for energy crops</td>
</tr>
<tr>
<td>2005 USDA agricultural baseline and 2000 forestry RPA/TPO</td>
<td>2010 USDA agricultural baseline 2010 FIA inventory and 2007 forestry RPA/TPO</td>
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<tr>
<td>Erosion constraints for forest residues</td>
<td>Greater erosion plus wetness constraints for forest residues</td>
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Contributors to the Billion-Ton Update

- Oak Ridge National Laboratory - 10
- Idaho National Laboratory - 3
- Agricultural Policy Analysis Center (University of Tennessee) - 5
- Navarro Research & Engineering (DOE Golden Field Office) - 1
- USDA/Forest Service - 13
- USDA/ARS - 7
- USDA/NRCS - 1
- USDA/NIFA - 1
- Iowa State University - 1
- Kansas State University - 1
- State University of New York – 3
- Texas A&M – 1
- University of Illinois - 1
- University of Minnesota - 2

Summary:
- 50 contributors
- 2 Labs (ORNL & INL)
- 4 USDA agencies
- 7 Universities

Reviewers
- 3 USDA
- 4 University
- 1 National Council
- 1 National Institute
- 2 International

Energy Crop Chapter Authors:
- Grasses – Mitchell and Vogel, ARS
- Miscanthus – Voigt, U. IL
- Sugarcane – Richard, ARS
- Sorghum – Rooney, TX A&M
- Poplar – Riemenschneider, U. MN
- Willow – Volk and Abrahamson, SUNY
- Eucalyptus – Langholtz, ORNL
- Southern Pine – Wright, ORNL

Associated Efforts

http://bioenergykdf.net
How Much Biomass is Available?

Feedstock; price, year, yield assumptions (scenarios); current use status; geography

Scenarios
- Baseline
- High-yield
  - 2%, 3%, 4% annual growth

Use Status
- Currently used
- Potential

Year
- 2010 (base)
- 2017
- 2022
- 2030

Scale
- National
- Regional
- State
- Multi-county
- County

The Taxonomy of Biomass Feedstocks

Biomass Resources

Primary Forestland resources
- Fuelwood (Currently used)
- Composite operations
- Logging residue
- Thinnings (timberlands)
- Other removal residue
- Thinnings (other forestlands)
- Conventional products

Primary Cropland resources
- Grain crops (Currently used)
- Oil crops (Currently used)
- Agricultural crop residues
- Perennial grasses
- Woody crops
- Annual energy crops
- Pulping liquors (Currently used)
- Mill residues (Currently used)
- Unused mill residue
- Crop processing residues
- Waste oils & greases
- Animal manures
- Urban wood wastes

Secondary residues & waste resources
General Approach

Supply curves are estimated at the roadside (farmgate, landing) as bales or chips

- Resource acquisition costs
  - Grower payments for crop residues
  - Production costs for dedicated energy crops
  - Stumpage costs for forest residues and conventional wood

- Collection and harvest costs
  - INL, ORNL, EcoWillow models for cropland resources
  - FRCS model revised to handle small trees, tops & limbs in all regions

- Key technical and factor input cost data, enhancement of models (e.g., POLYSYS), and analyses developed through coordination among partners

County-level feedstock supply curves for major primary agriculture and forest resources

1. For primary agriculture resources - Crop residues and energy crops (supply curves)
   - POLYSYS- Policy Analysis System Model
   - Based on NASS, USDA Census data, USDA Agricultural Baseline projections
   - Predicts optimal farm land use with the additional option of collecting annual residues or choosing purpose grown energy crops

2. For primary forest resources - Resource cost analysis used to estimate supply curves
   - Based on USDA/FS data (FIA, TPO, RPA, ...); meet RPA projections for pulp, timber, veneer
   - Resource constraints include forest residue access, recovery, and merchantability
   - Requirements for resource environmental sustainability
Agricultural Resources

Calibrated OBP version of POLYSYS – dynamic, county-level model of the U.S. agricultural sector

- POLYSYS is anchored to the USDA Baseline Forecasts
- 451 million acre land base - Cropland (250 million acres); Cropland used as pasture (22 million acres); Hayland (61 million acres); Permanent pasture (118 million acres)
- Includes detailed cropping budgets (traditional and dedicated energy crops)
  - Estimated discounted average cost of production
  - Established yield potentials from published literature
  - Identified land suitability (constraints) for sustainable production
  - Energy Crops compete with traditional crops for acreage
  - Forest resources exogenous to the model

To create biomass supply curves POLYSYS is run at a set of feedstock prices ($40 to $60/dry ton at $5 increments)
- POLYSYS calculates the land use (acreage of land type) in each county that will simultaneously
  - maximize farmer profit
  - meet USDA baseline production of 8 major crops and livestock demands
  - meet sustainability requirements for residue removal

Reference:
University of Tennessee - Agricultural Policy Analysis Center (APAC)
(http://www.agpolicy.org/)
Crop Residues

Residue Sustainability

- Residue retention coefficients estimated using RUSLE2, WEPS, and SCI for erosion and soil carbon
  - Separate coefficients for acres under reduced till and no-till cultivation

Crop Residues

- Threshold grower payments – based on nutrient replacement cost (fertilizer) plus organic matter (~$15/dry ton) plus $10/dry ton (regional variability due to regional variation in fertilizer prices)
  - Apply to stover and straws
- Crop residue collection costs
  - Sensitive to amount removed/acre; decreases exponentially as removal amount increases
Herbaceous crop yields
2010 yield = 3 – 9.9;
2030 yield = 3.6 – 12.0
(baseline scenario)

• Woody crops (poplar, pine, eucalyptus, willow)

Woody crop yields
2010 yield = 3.5 – 6;
2030 yield = 4.2 – 7.2
(baseline scenario)
Dedicated Energy Crops: Costs

- Production costs
  - Planting (site prep, materials, etc)
  - Maintenance (weed control, fertilization, etc)
- Harvesting
  - Herbaceous crops (mow, rake, bale, move/stack roadside)
  - Non-coppice woody crops (fell, bunch, chip)
  - Coppice woody crop (continuous cut and chip)

Dedicated Energy Crops: Sustainability

- Energy crops allowed on non irrigated land
- Minimal tillage, fertilizer and herbicide applications
- Used BMPs for establishment, cultivation, and harvesting
- Some intensification of pasture land required (Management Intensive Grazing) to meet lost forage when energy crops displaced pasture
**Forestland resources**

504 million acres of timberland, 91 million acres of “other forestland”

<table>
<thead>
<tr>
<th>Types</th>
<th>Source</th>
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<tr>
<td>Timberland- Logging residues</td>
<td>FIA plots (federal &amp; nonfederal lands)</td>
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<tr>
<td>Timberland- Fuel treatments</td>
<td>FIA plots (federal &amp; nonfederal lands)</td>
</tr>
<tr>
<td>Timberland - Conventional wood (pulp)</td>
<td>FIA plots (federal &amp; nonfederal lands)</td>
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<tr>
<td>Timberland - Land clearing &amp; silvicultural treatments</td>
<td>FIA plots (federal &amp; nonfederal lands)</td>
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<tr>
<td>Thinnings from “other forestland” (&lt;20f3/yr) e.g pinyon juniper</td>
<td>FIA plots (federal &amp; nonfederal lands)</td>
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<tr>
<td>Fuelwood*</td>
<td>EIA</td>
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<td>Primary Mill residues*</td>
<td>TPO</td>
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<tr>
<td>Secondary mill residues*</td>
<td>EIA, Surveys</td>
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<td>Pulping liquors*</td>
<td>EIA</td>
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<tr>
<td>Urban wood residues</td>
<td>EPA and ISFS Forest Products Lab</td>
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* Fraction in current use are considered not available

**FiA-based forest resources**

- Evaluated the “state-of-the-science” for biomass removal
  - erosion, soil nutrients, biodiversity, soil-organic carbon, and long-term soil productivity
- Developed woody retention levels by slope classes within context of a science review
- Projections based on 2007 RPA/TPO (accessed February 2010)
**Forestland resources**

Sustainability assumptions for forest residue retention

- Logging residues
  - 30% left on-site
- Fuel treatment thinnings
  - Slope <40% = 30% of residue is left on-site
  - Slope >40% to <80% = 40% of the residue left on site
  - Slope >80% = no residue is removed (no limbs or tops yarded)
- Removed steep, wet and roadless sites

**Forestland resources**

FIA-based forest resources

- ~37,000 permanent field plots
- All fire regime condition classes
- Forests could have fuel treatment if stand density greater than 30% of maximum stand density for forest type/region
- Thin over 30-year period
Scenarios (1 of 3)

• Baseline scenario assumptions
  – Published USDA Baseline forecast for crop yields, acres, etc.
  – Baseline forecast extended to 2030 based on trends in last 3-years of published forecast
  – Stover to grain ratio of 1:1 assumed
  – National corn yield average of 160 bu/ac in 2010 and assumed to increase to 201 bu/ac in 2030

Scenarios (2 of 3)

• Baseline scenario assumptions (continued)
  – Assumes a mix of conventional till (CT), reduced till (RT), and no-till (NT)
    • For corn
      – 2010 – 38% conventional till, 43% reduced till, 20% no-till
      – 2030 – 34% conventional till, 43% reduced till, 23% no-till
    • No residue collected on conventionally tilled acres
  – Energy crop yields increase of 1% annually (determined by year of planting)
    • Yield growth attributed to learning by doing in energy crops and limited R&D
### Scenarios (3 of 3)

- **High-yield scenario(s) assumptions**
  - Corn yields increase to 265 bu/acre in 2030 (national average)
  - Higher amounts of cropland in no-till cultivation allow greater residue removal
  - Energy crop yields increase at 2%, 3%, and 4% annually
    - Higher yields attributed to more aggressive R&D

### Final Comments

- Energy crops displace mostly commodity crops at low prices
- Significant quantities of pasture (cropland pasture and permanent pasture) are displaced at higher prices
- Lost forage needs to be replaced
  - Growing of additional hay (alfalfa)
  - Intensification of pasture (e.g., management intensive grazing, rotational grazing, etc.)
  - Both
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