



... from Grow to Go!

Switchgrass as a Bioenergy Crop

Alternative Energy 2009:
Sustainable Development in a Challenging Economy
Louisiana State University, Center for Energy Studies
April 22, 2009

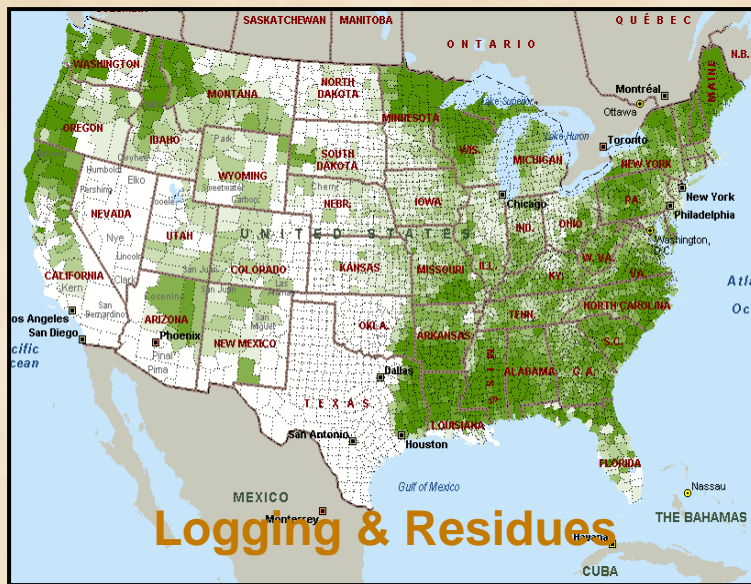
Kelly Tiller, Ph.D.

President & CEO
Genera Energy LLC

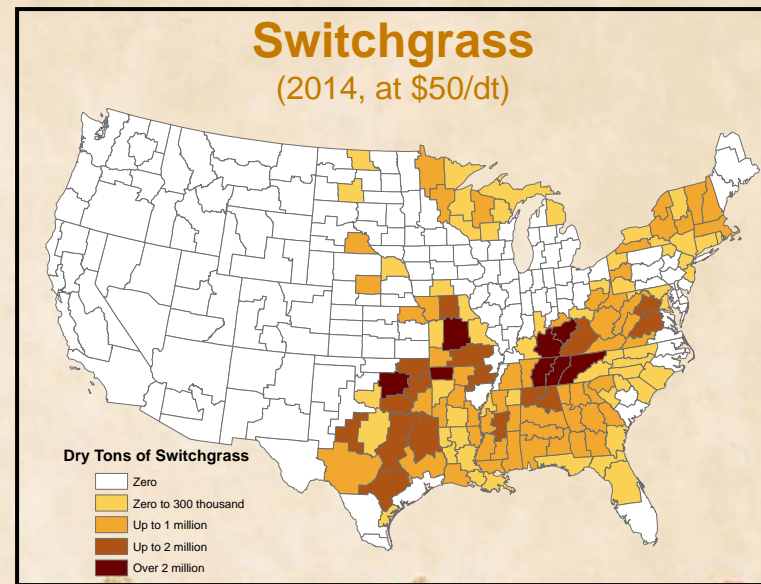
Director of External Operations
Office of Bioenergy Programs
University of Tennessee



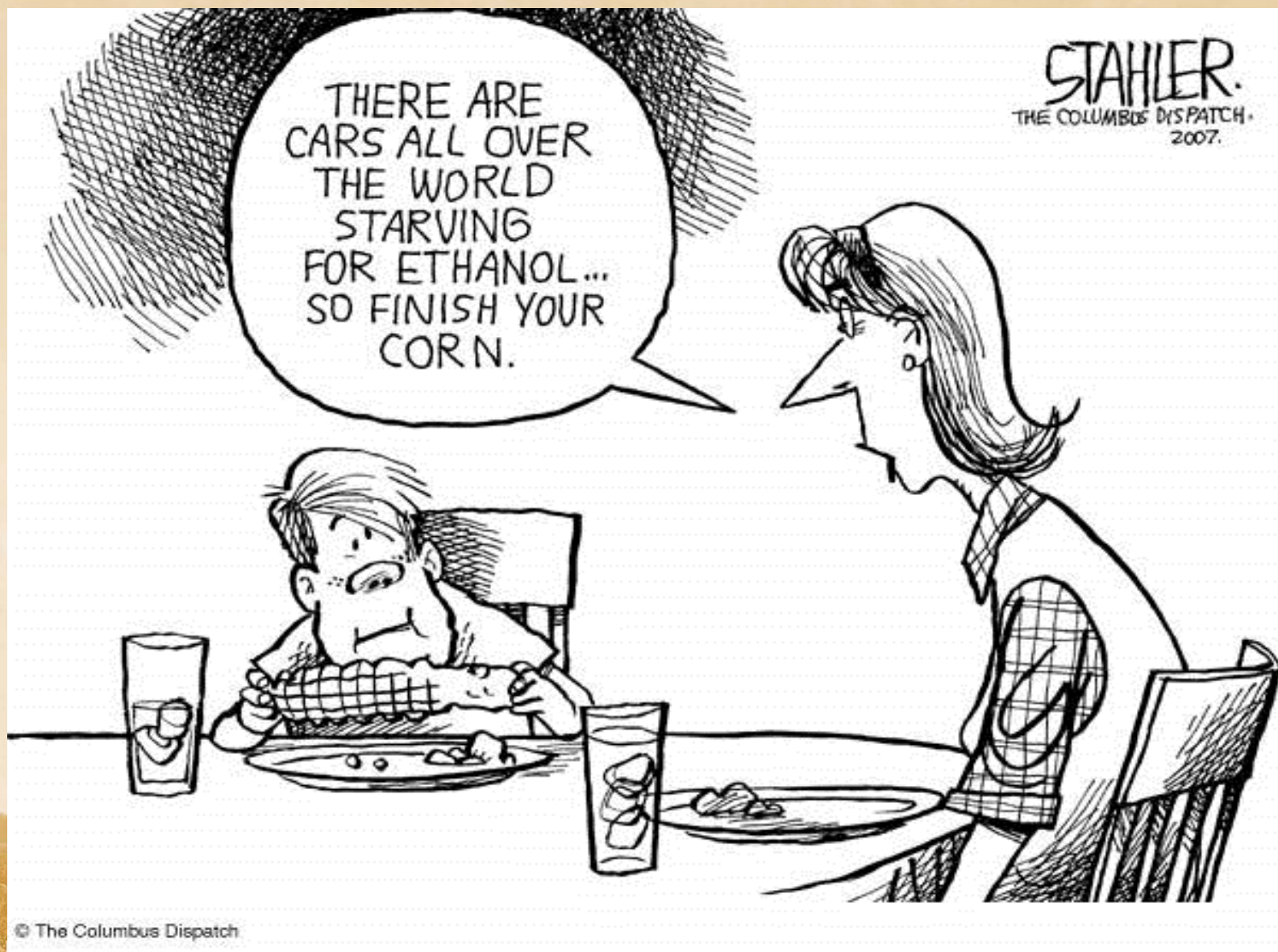
Southeast: A Biomass Advantage



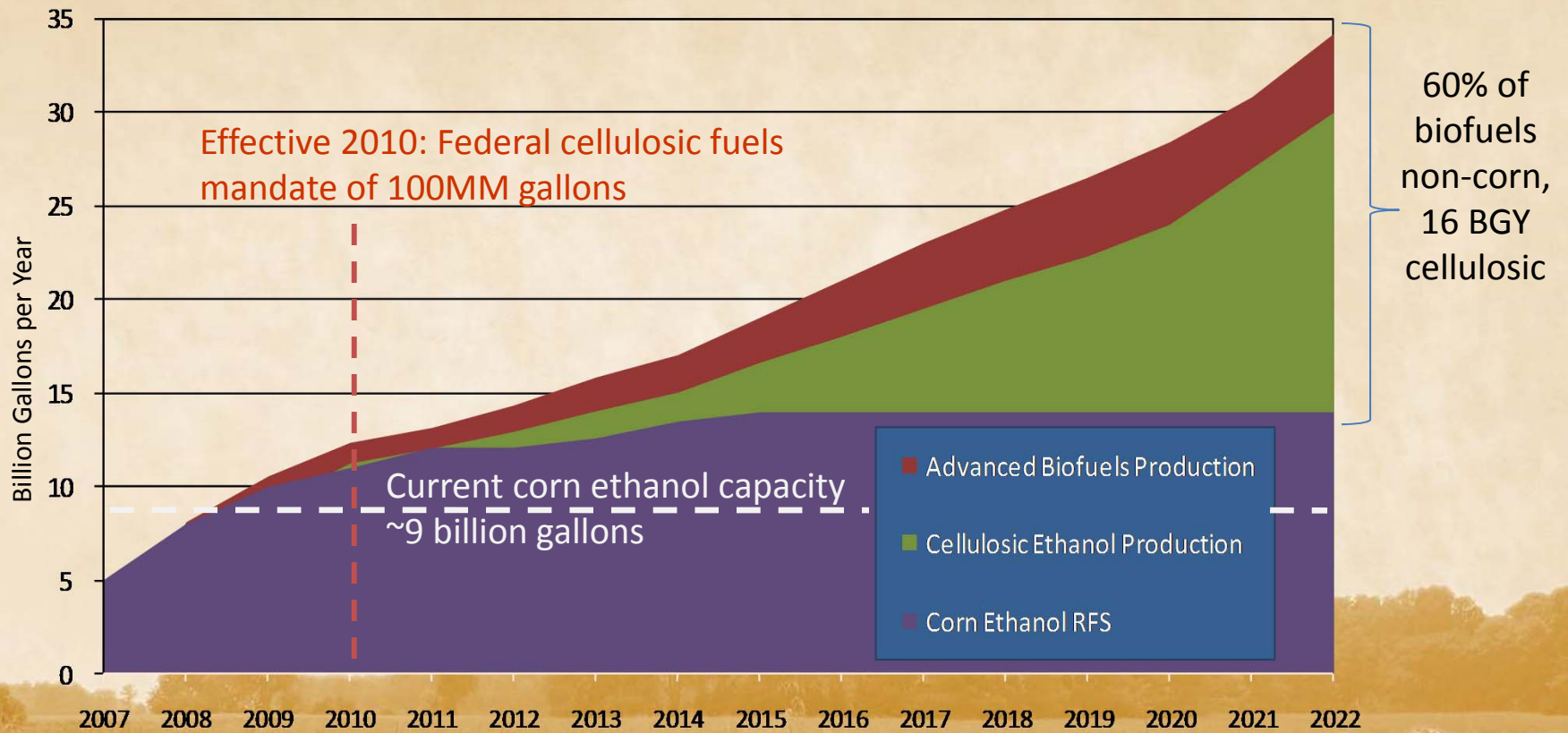
Perlack, R.D., et al. 2005. Biomass as Feedstock for a Bioenergy and Bioproducts Industry: Technical Feasibility of a Billion-Ton Annual Supply.



Ugarte, et al. 2006. Economic Implications to the Agricultural Sector of Increasing the Production of Biomass Feedstocks to Meet Biopower, Biofuels and Bioproduct Demands.



Expanded Renewable Fuels Mandate



Comprehensive Approach

Energy Crops

Biochemical
Conversion

Consumer
Products

Industrial
Processing



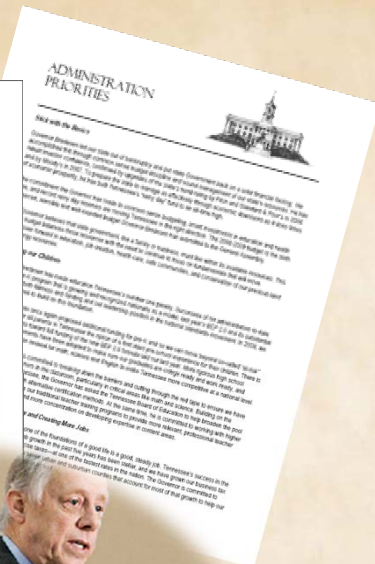
Integration is Key

- **Integrated objectives require strategic partnerships:**
 1. **Demonstrate the establishment of a dedicated biomass energy crop supply chain with farmers**
 2. **Demonstrate the pre-commercial production of ethanol from switchgrass**
 3. **Establish premier long-term research capability in bioenergy and bioproducts**
 4. **Develop a viable, sustainable, long-term path to commercialization of cellulosic biofuels in Tennessee**



State of Tennessee Commitment

FY09 Improvements	
Highlights of Major Improvement Initiatives	
Education <small>(Includes BEP 2.0 Year 2, Pre-K Expansion, Academy for Health & Science Year 2, Bonds From BRN Health Insurance, Save the Children Literacy Program Year 3, FFA and 4H Foundations Grants, HOPE Scholarship Reauthorization, Housing Loans Forgiveness Program, UT Eastlands Year 2, Teacher Quality Initiative, Teacher and Higher Education Salary Increases)</small>	\$ 287 M
Job Creation/Rural Development <small>(Includes Soil Conservation, Tourism Advertising, Jobs Package, Rural Opportunity Fund)</small>	\$ 37.6 M
Home and Community Based Care <small>(Includes Home and Community Based Services, Assisted Community Based Rehabilitation Services, Community Based Health Services Working Unit Reauthorization)</small>	\$ 20.7 M
Safe Communities <small>(Includes Justice Safety DNA Analysis, Recreational Trail Jobs, Inland-Cross Agency Children Task Force, Inland-Cross Agency National Guard Youth Challenge Program, Communications Interoperability, and Fire Fighting Communications Equipment)</small>	\$ 41.9 M
Energy and Conservation <small>(Includes Alternative Fuels Incentives (Bio-ETER) Year 2, Heritage Conservation Trust Fund, Local Parks and State Lands Acquisition Funds, Water Resource Management, Wetlands Acquisition Fund, UT Research Research Initiative)</small>	\$ 34.5 M

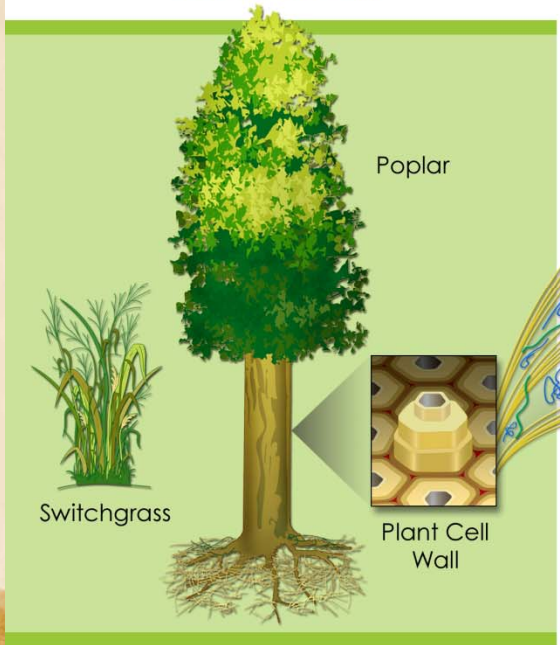


- Significant 5-year funding commitment totaling \$70.5 million
 - \$60 million appropriated to date
- Sustained commitment
- Business-like approach
- University led and managed; leverages partnerships
- Complements BioEnergy Science Center at ORNL, Southeastern Sun Grant Center

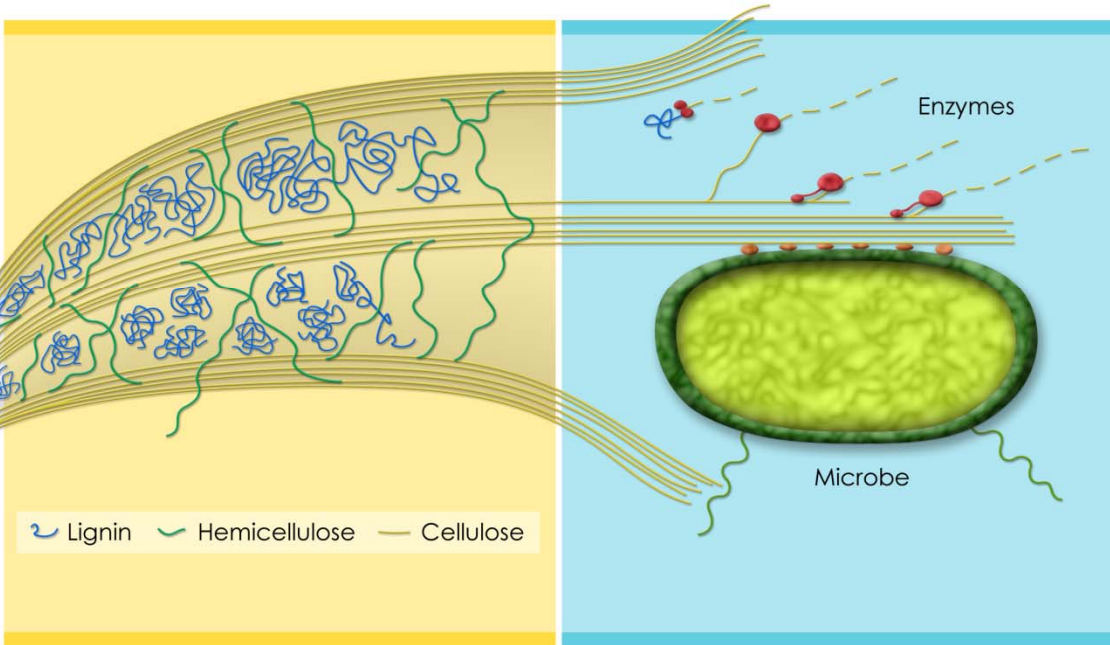


A Two-Pronged Approach

Modify the plant cell wall structure to increase accessibility

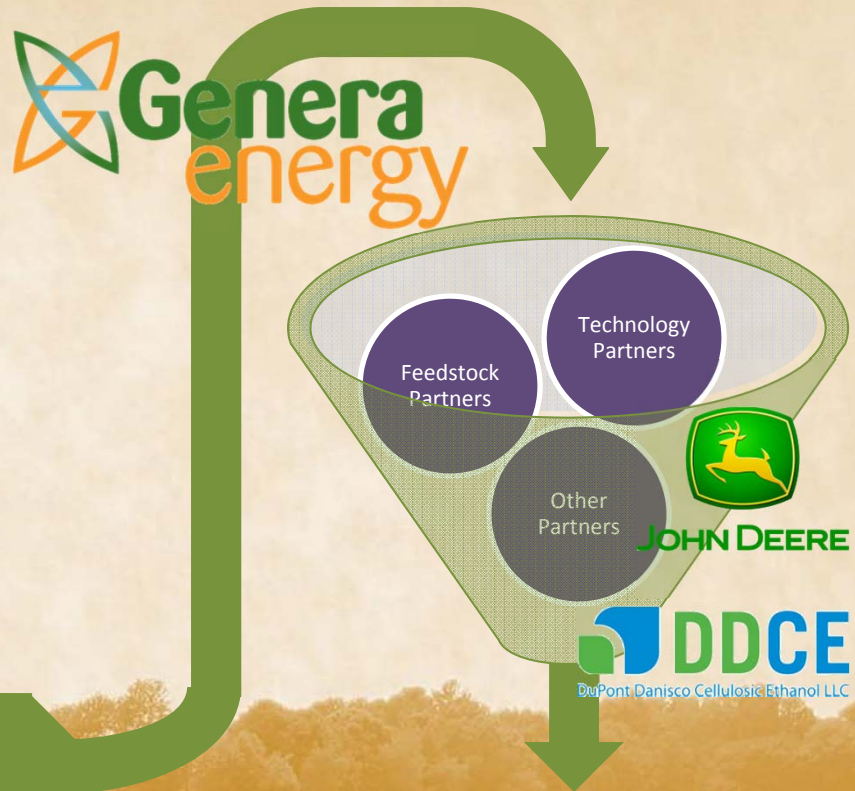
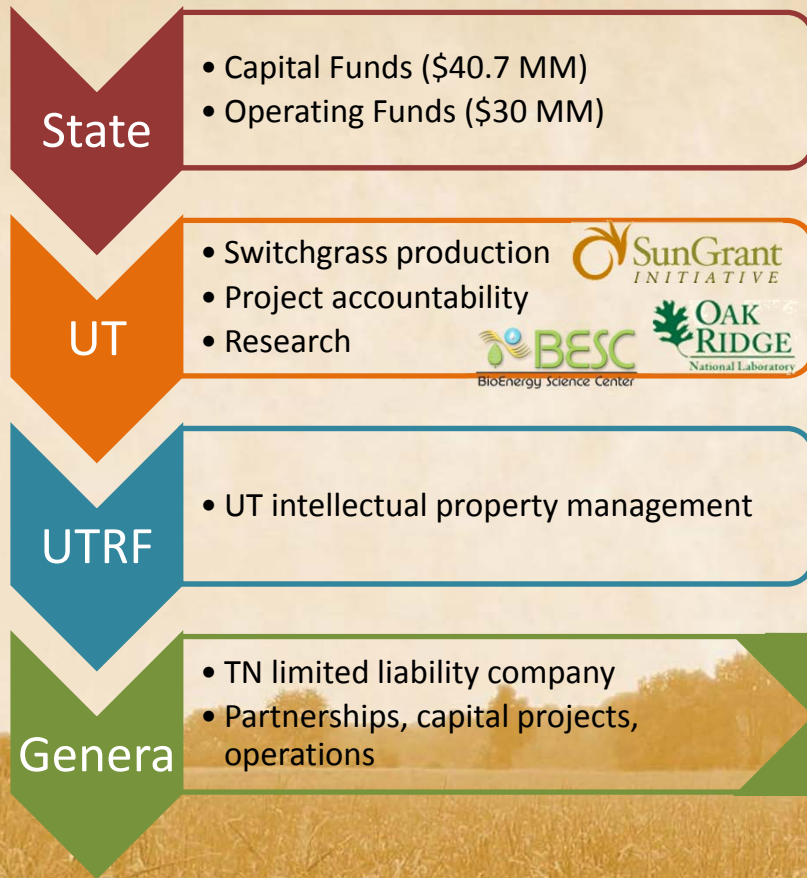


Improve combined microbial approaches that release sugars and ferment into fuels



Both utilize rapid screening for relevant traits followed by detailed analysis of selected samples

Enabling Partnerships



Demonstration, Improvements, Scale-Up, Commercialization



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Switchgrass Focus

- Well suited to the Southeast
 - Currently, ~6-8 tons/acre in TN
 - Potential for 12+ tons/acre
- Warm season, native, perennial grass
- Tolerates poor soils, flooding, drought
- Highly resistant to many pests and plant diseases
 - Low use of chemicals or fertilizers
- 1-2 year establishment
 - Weed control critical in establishment
- Initial production practices similar to hay
 - Working toward next generation harvest, storage, management improvements
- UT has long history of switchgrass production and market research



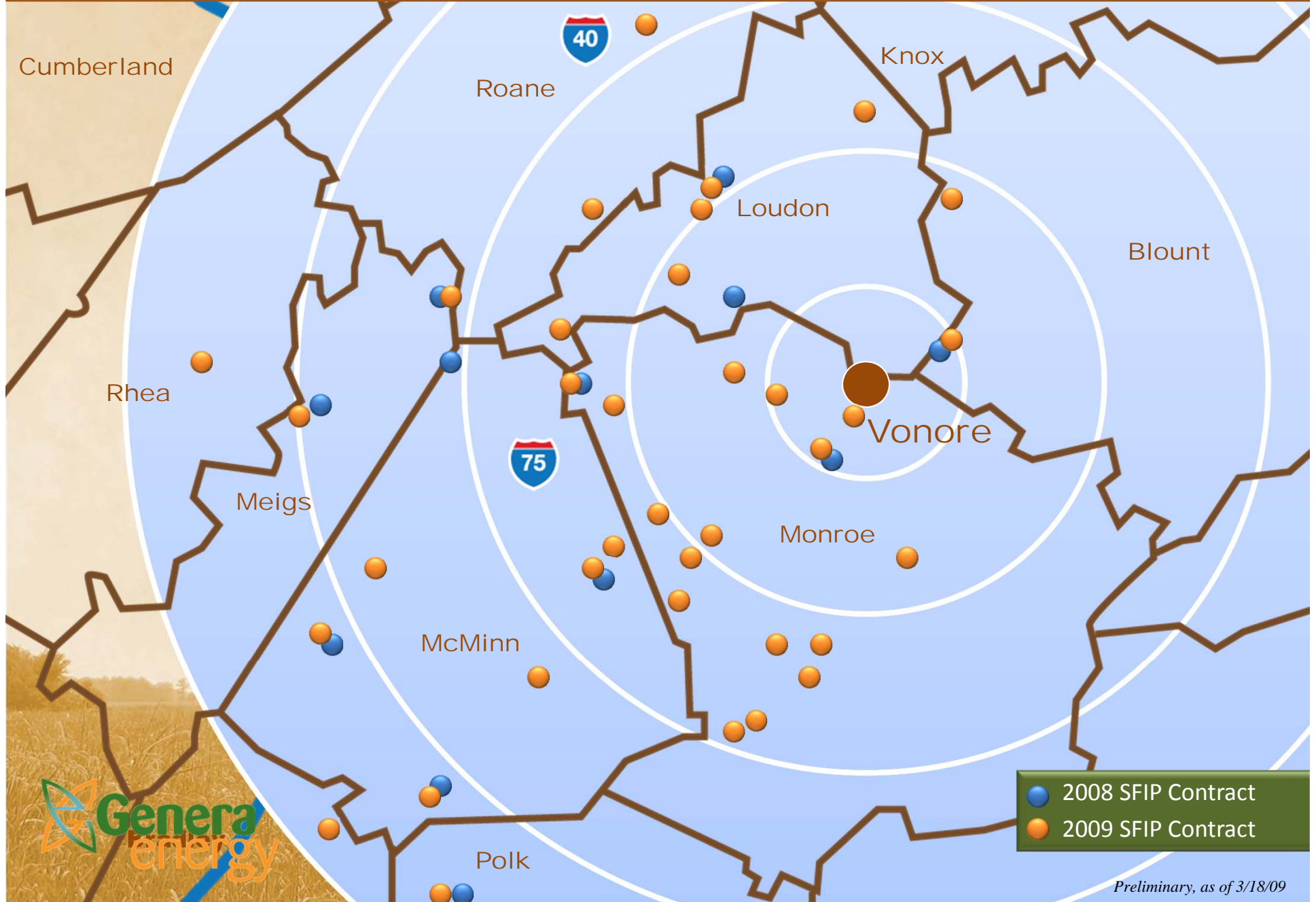
Farmer Incentive Program

 Extension

- Payment for costs of production and opportunity costs
 - Acreage based 3-year contract
 - \$450/acre/year
 - We provide seed, technical expertise
- First round: 2008
 - 200+ farmers participated, ~2,000 acres
 - Contracted 723 acres on 16 farms
 - Averaged 2 tons/acre (0 to 5+ tons/acre)
- Second round: 2009
 - 63 complete applications, ~3,500 acres
 - Contracted 1,950 acres on 37 farms
- Incentive program totals \$12.5 million over 5 years



Switchgrass Contract Farms



Feedstock for Fuels



- Commercial cellulosic biofuels require:
 - Adequate, sustainable feedstock supply
 - Consistent feedstock quality
 - Economical supply chain
- Research & demonstration needed in:
 - Crop development
 - Farm production
 - Harvesting and storage
 - Transportation and logistics
 - Feedstock quality
 - Feedstock characterization
 - Environmental factors

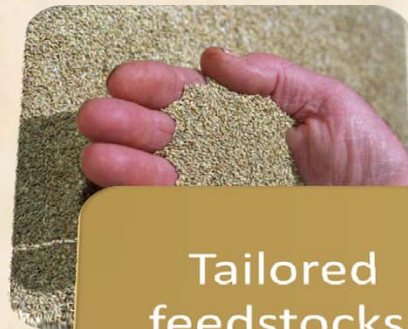


Biomass Productivity

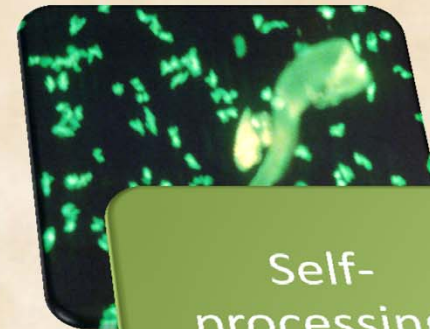
Cellulosic ethanol will not happen overnight ... more and better feedstock from existing crops will be necessary to maintain the momentum of renewable fuels.



Existing
feedstocks,
increase yields



Tailored
feedstocks,
genetic
improvements



Self-
processing,
designer
feedstocks

“Bioengineering” Work Needed

Lots of opportunity for improving supply chain efficiencies



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Pilot Biorefinery



- Collaboration with DuPont Danisco Cellulosic Ethanol, LLC
- Vonore location: Nilis Ferry Industrial Park, Monroe County, 32 acres
- Optimized as precursor to commercial demonstration (~20 MGY)
- Pilot plant (250,000 gpy) and Process Development Unit (PDU)
- Long-term operation as an RD&D facility

- Owned by Genera Energy, operated by DDCE
- DDCE proprietary integrated process solution
- Expect completion, ethanol production by end of 2009
- Multiple feedstocks: cob and switchgrass
- Both Pilot & PDU operational by end of 2009
- Flexibility in process design, operation



Artist Rendering: Gresham Smith & Partners, January 2009



Switchgrass to Ethanol

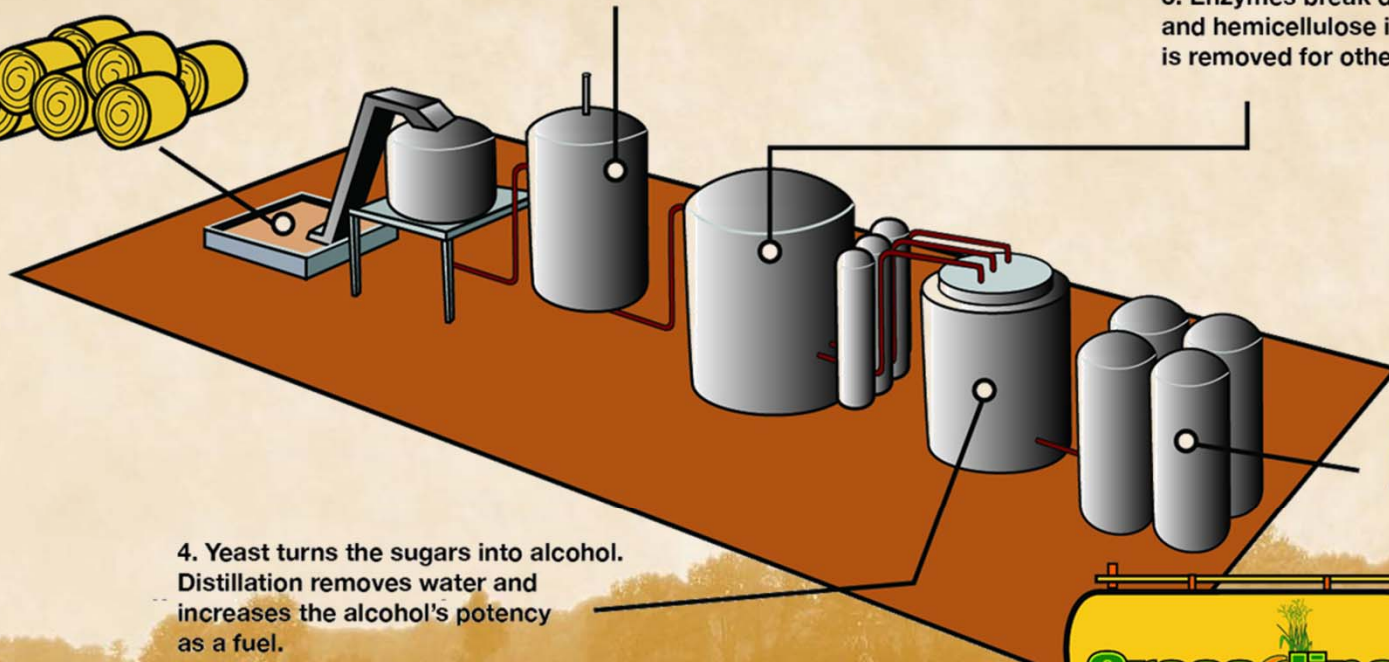
1. Switchgrass, wood chips and other biomass arrive at the biorefinery.

2. Steam and pressure separate shredded biomass into cellulose, hemicellulose and lignin.

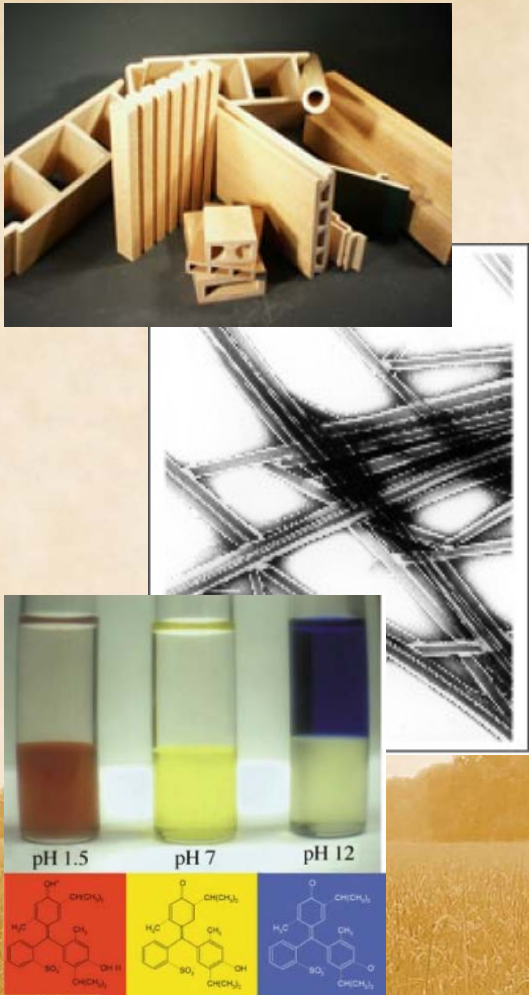
3. Enzymes break down cellulose and hemicellulose into sugars. Lignin is removed for other products.

4. Yeast turns the sugars into alcohol. Distillation removes water and increases the alcohol's potency as a fuel.

5. Cellulosic ethanol (Grassoline) is transported to consumer outlets.



Coproduct Utilization



- Lignin and solid residue will initially provide heat and energy for the process
- Product diversification is considered important to economic viability of the biorefinery
- Research will address development of chemical building blocks and novel, value-added products

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Existing & Planned U.S. Cellulosic Biorefineries



Source: 2009, <http://biofuelsandclimate.wordpress.com/about/>



Key Challenges for the Biofuels Industry

- Biomass availability, cost
- Economic competitiveness
- Investment capital for buildout
- Supportive, sustained policy
- Distribution infrastructure



Biomass Technologies & Products



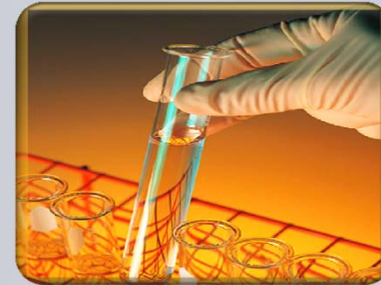
Power

- Co-fire
- Direct fire
- Gasification
- Bio-char
- Hydrogen



Fuel

- Ethanol
 - Biochemical
 - Thermochem
- F-T Diesel
 - Syngas
 - Pyrolysis
- Hydrogen

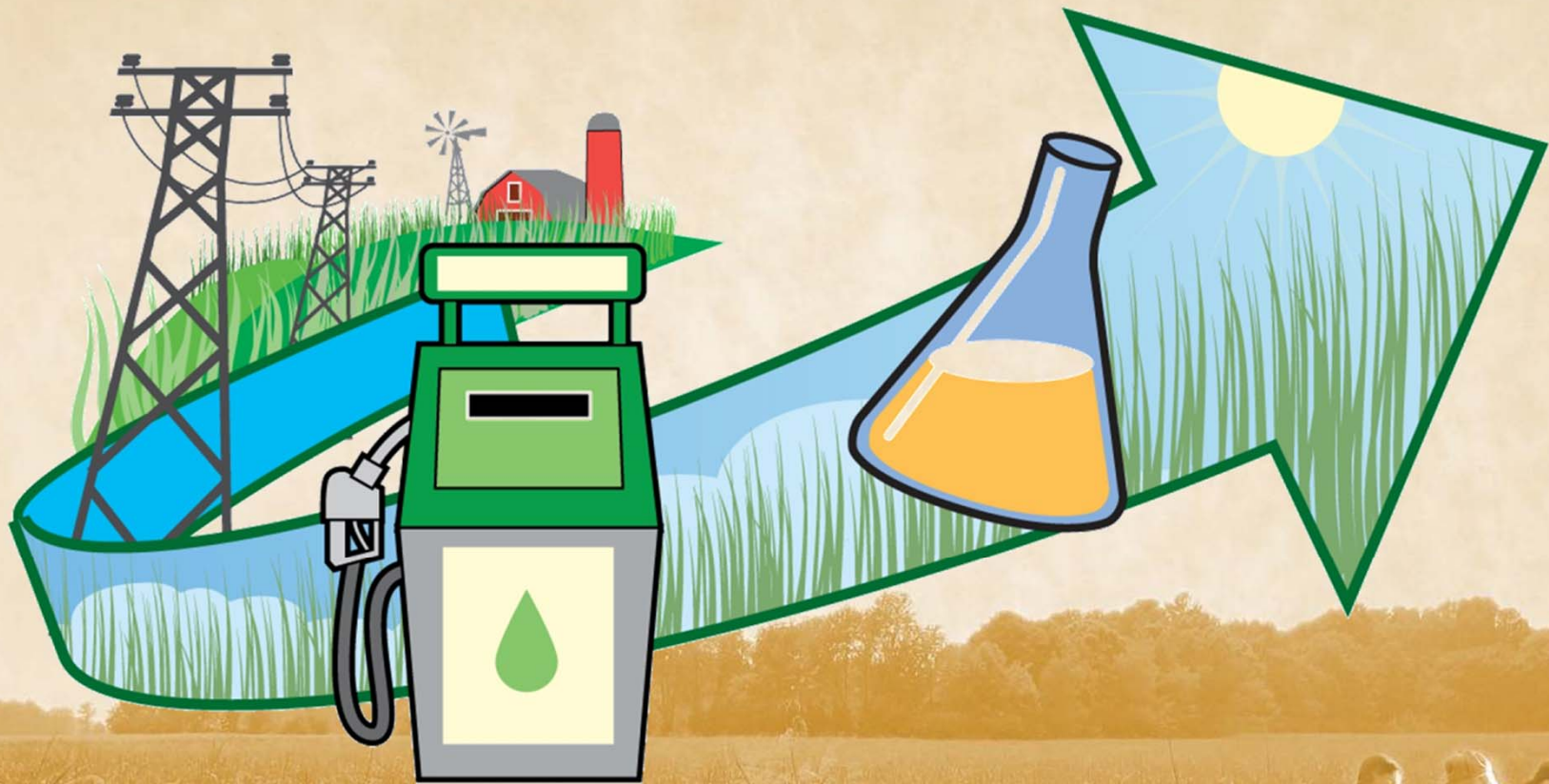


Products

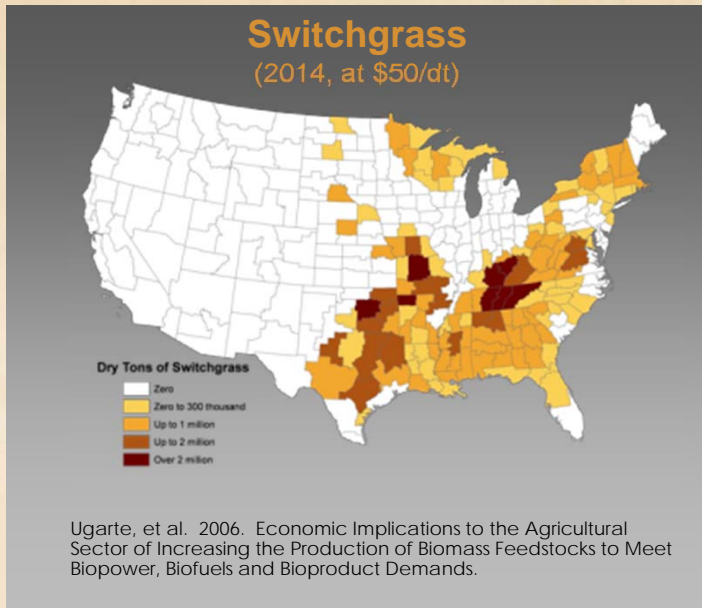
- Lignin
 - Carbon fiber
 - Chemicals
- Sugars
 - Platform chemicals
- Molecular transformations



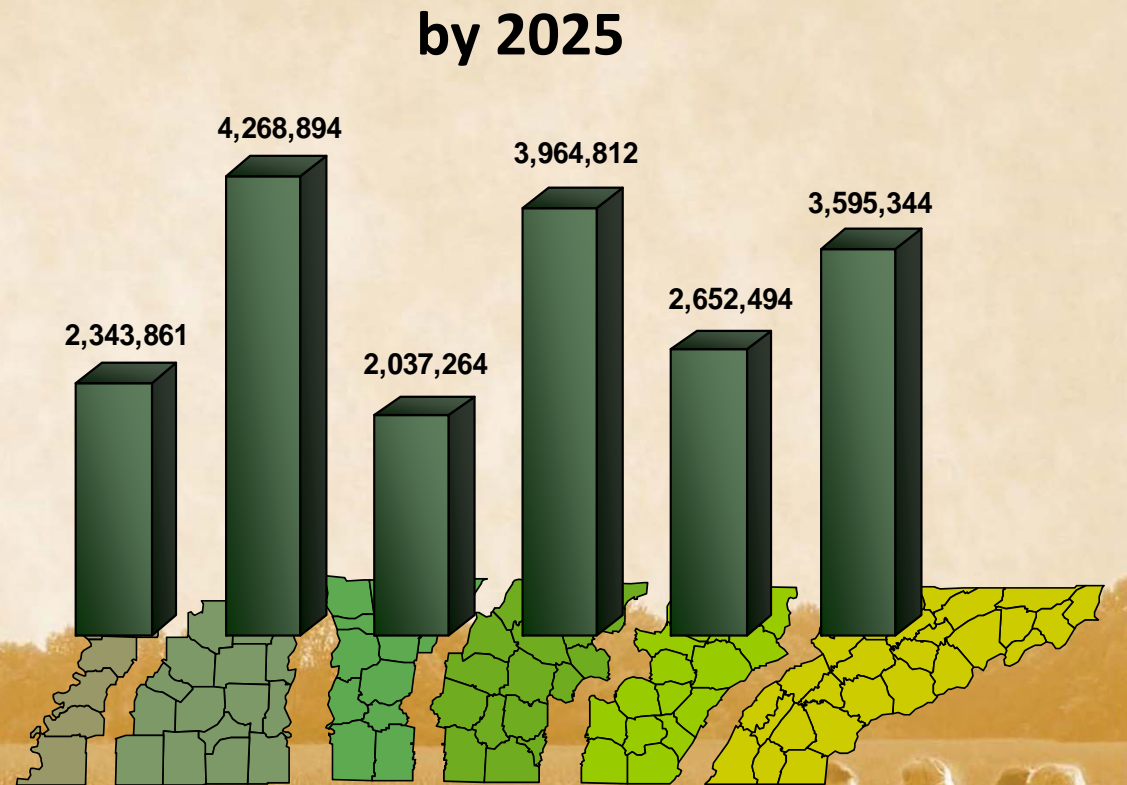
Biomass: The Common Denominator



TN Switchgrass Potential



- Dry tons of switchgrass
- Assuming \$40/dt at the farm gate
- Assuming yields around 6 dt/acre
- Without disrupting sector balance



The Gap: Arm-Chair Farming

“
Farming looks mighty
easy **when your plow**
is a pencil, and you are
a thousand miles from
the corn field. ”



Dwight Eisenhower



Vision: Million Acre Portfolio

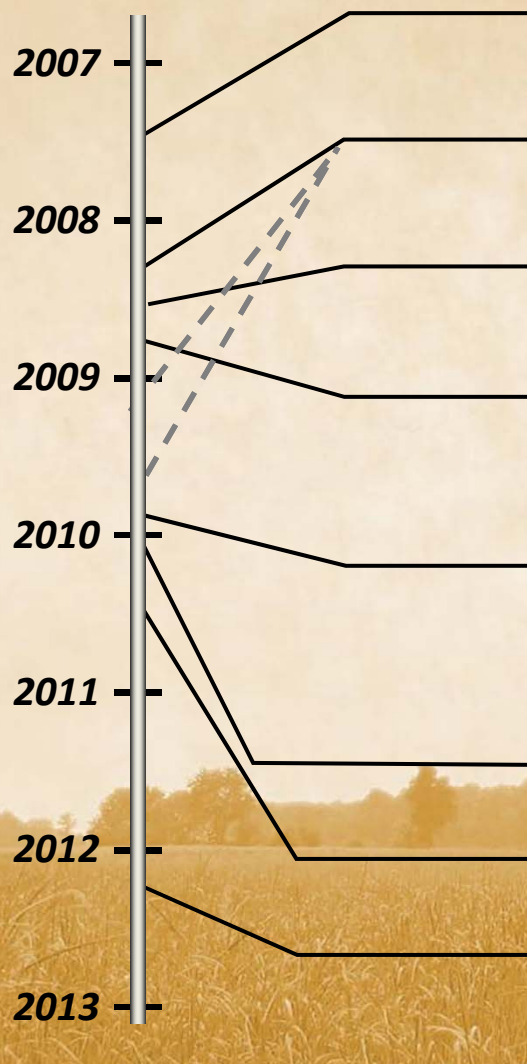


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Integrated Business Supply Solution



The Pathway Forward



- State funding approved
- Initial switchgrass plantings (723 acres 2008, + ~2,000 acres 2009, + ~3,000 acres 2010)
- Partnership with DDCE
- Groundbreaking for pilot biorefinery
- 12-14 month construction phase
- First gallon of Grassoline produced
- Launch integrated business solution for biomass supply
- Commence pellet mill operations
- First commercial-scale (~20 MGY) cellulosic ethanol facility in TN



Tennessee Leading by Example



www.UTbioenergy.org



Institute of Agriculture ♦ Office of Bioenergy Programs

