Switchgrass as a Bioenergy Crop

Alternative Energy 2009:
Sustainable Development in a Challenging Economy
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Kelly Tiller, Ph.D.

President & CEO
Genera Energy LLC

Director of External Operations
Office of Bioenergy Programs
University of Tennessee
Southeast: A Biomass Advantage

Logging & Residues


Ugarte, et al. 2006. Economic Implications to the Agricultural Sector of Increasing the Production of Biomass Feedstocks to Meet Biopower, Biofuels and Bioproduct Demands.
THERE ARE CARS ALL OVER THE WORLD STARVING FOR ETHANOL... SO FINISH YOUR CORN.
Expanded Renewable Fuels Mandate

Effective 2010: Federal cellulosic fuels mandate of 100MM gallons

Current corn ethanol capacity ~9 billion gallons

60% of biofuels non-corn, 16 BGY cellulosic

Institute of Agriculture  Office of Bioenergy Programs
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

- 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

- Poplar
- Switchgrass

Plant Cell Wall

Lignin  Hemicellulose  Cellulose

Improve combined microbial approaches that release sugars and ferment into fuels

Enzymes

Microbe

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

Source: Institute of Agriculture • Office of Bioenergy Programs
Enabling Partnerships

**State**
- Capital Funds ($40.7 MM)
- Operating Funds ($30 MM)

**UT**
- Switchgrass production
- Project accountability
- Research

**UTRF**
- UT intellectual property management

**Genera**
- TN limited liability company
- Partnerships, capital projects, operations

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
• 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
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
Cellulosic ethanol will not happen overnight … more and better feedstock from existing crops will be necessary to maintain the momentum of renewable fuels.
“Bioengineering” Work Needed

Lots of opportunity for improving supply chain efficiencies
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Pilot Biorefinery

- Collaboration with DuPont Dansico Cellulosic Ethanol, LLC
- Vonore location: Niles 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


Institute of Agriculture • Office of Bioenergy Programs
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

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

Aggregation
- Contract production
- Marketing

Storage
- Centralized storage
- Densification

Seed Production
- Cleaning, processing
- Marketing

Transportation
- Farm gate
- Intermediates
- Final products

Pre-Processing
- Chop, grind, hammermill
- Drying

Intermediate Processing
- Pelletization
- Pre-treatment, separations

Points of Value
- Resource sharing
- Pooling / marketing
- Logistics (storage, transport)
- Quality assurance
- Risk management
- Communication, advocacy

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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