

Growing a future of  
**CLEAN RENEWABLE ENERGY**



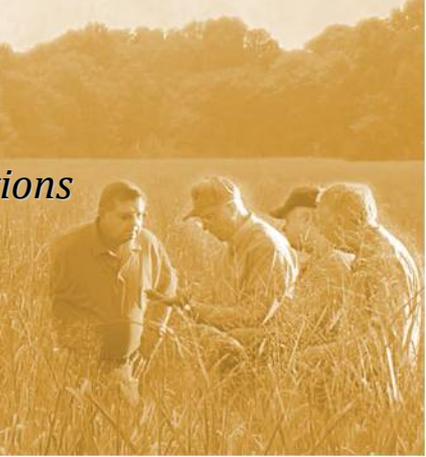
# Demonstration of a Large-Scale Integrated Switchgrass Supply Chain

March 30, 2010  
DOE Biomass 2010  
Washington, DC

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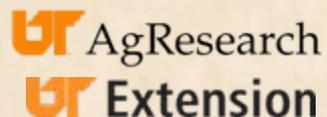
# Tennessee's Comprehensive Approach



## Energy Crop Supply Chain

*Demonstrate the establishment of a dedicated biomass energy crop supply chain with farmers*

- 6,000 acres of switchgrass



## Commercialization

*Develop a viable, sustainable, long-term path to commercialization of cellulosic biofuels in Tennessee*

- Biomass supply infrastructure



**\$70.5 Million State Commitment**

## Biofuels, Bioproducts R&D

*Establish premier RD&D capabilities and capacity in biofuels and bioproducts*



## Cellulosic Ethanol Biorefinery

*Demonstrate the pre-commercial production of ethanol from switchgrass*

- 250,000 gal biorefinery, Dec 2009



# State of Tennessee Commitment



- 5-year funding commitment: \$70.5M
  - \$40.7M capital (bricks & mortar) appropriated in 2007
  - \$29.75M committed for operations and farmer switchgrass programs
- Business-like approach
  - Created Genera Energy LLC to implement
- Leveraging state investment with private partners & federal grants (>\$163M since 2007)
  - DOE funded (\$135M) BioEnergy Science Center at Oak Ridge National Laboratory
  - Significant DDCE investment in biorefinery
  - Complements Southeastern Sun Grant Center (\$15M) R&D programs
  - \$4.9M DOE biomass high tonnage logistics grant
  - \$2.4M BRDI grant for improved switchgrass variety demonstration

# Switchgrass Focus

- Well suited to the Southeast
  - Currently, ~6-10 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
- Works with existing infrastructure
- May be removed, improves soil quality



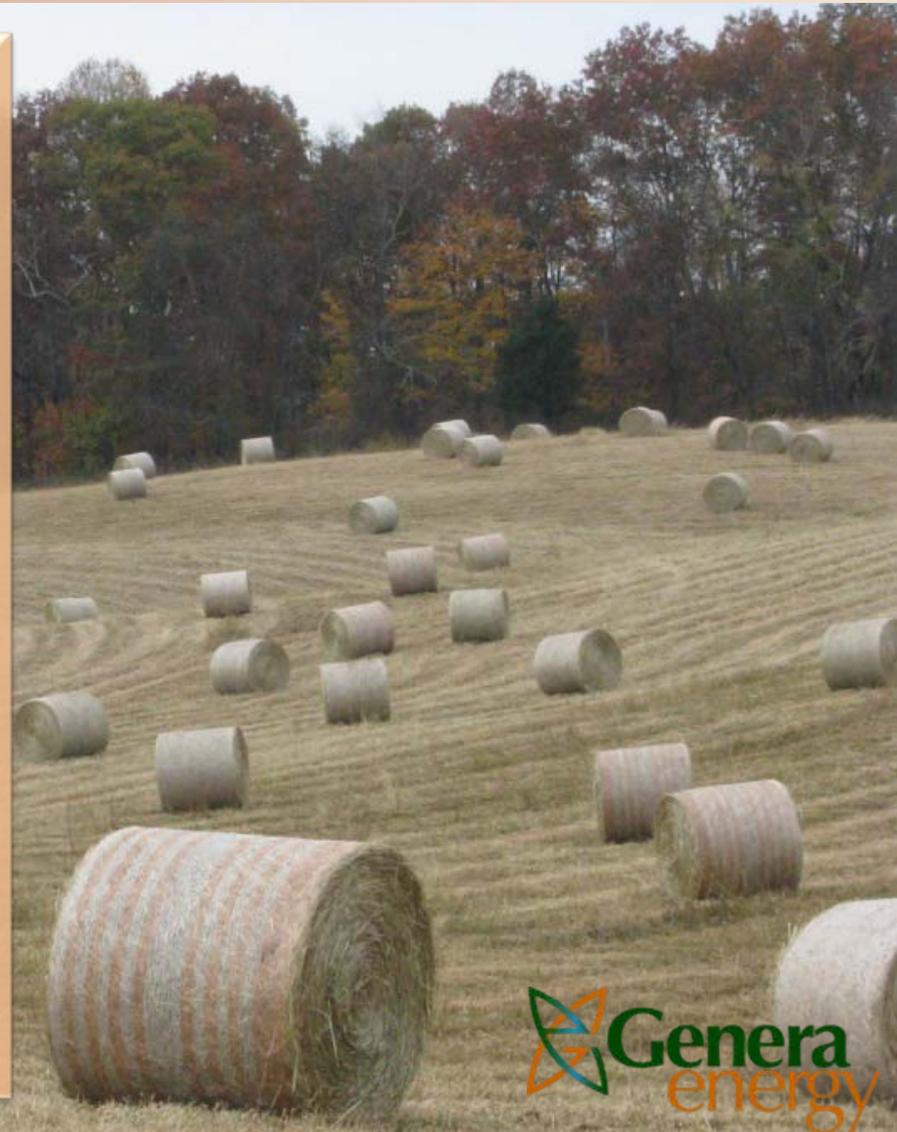
# Tenn. Switchgrass Experience

- Contracting with local farmers to produce nearly 7,000 acres of switchgrass
  - Nearly 3,000 acres harvested in 2009
  - Adding ~4,000 acres in 2010
- Averaging about 7-8 tons/acre by third year
  - Harvesting ~2 tons in year 1
  - ~5 tons in year 2
  - ~8 tons year 3 and beyond
- UT Extension partners have been invaluable

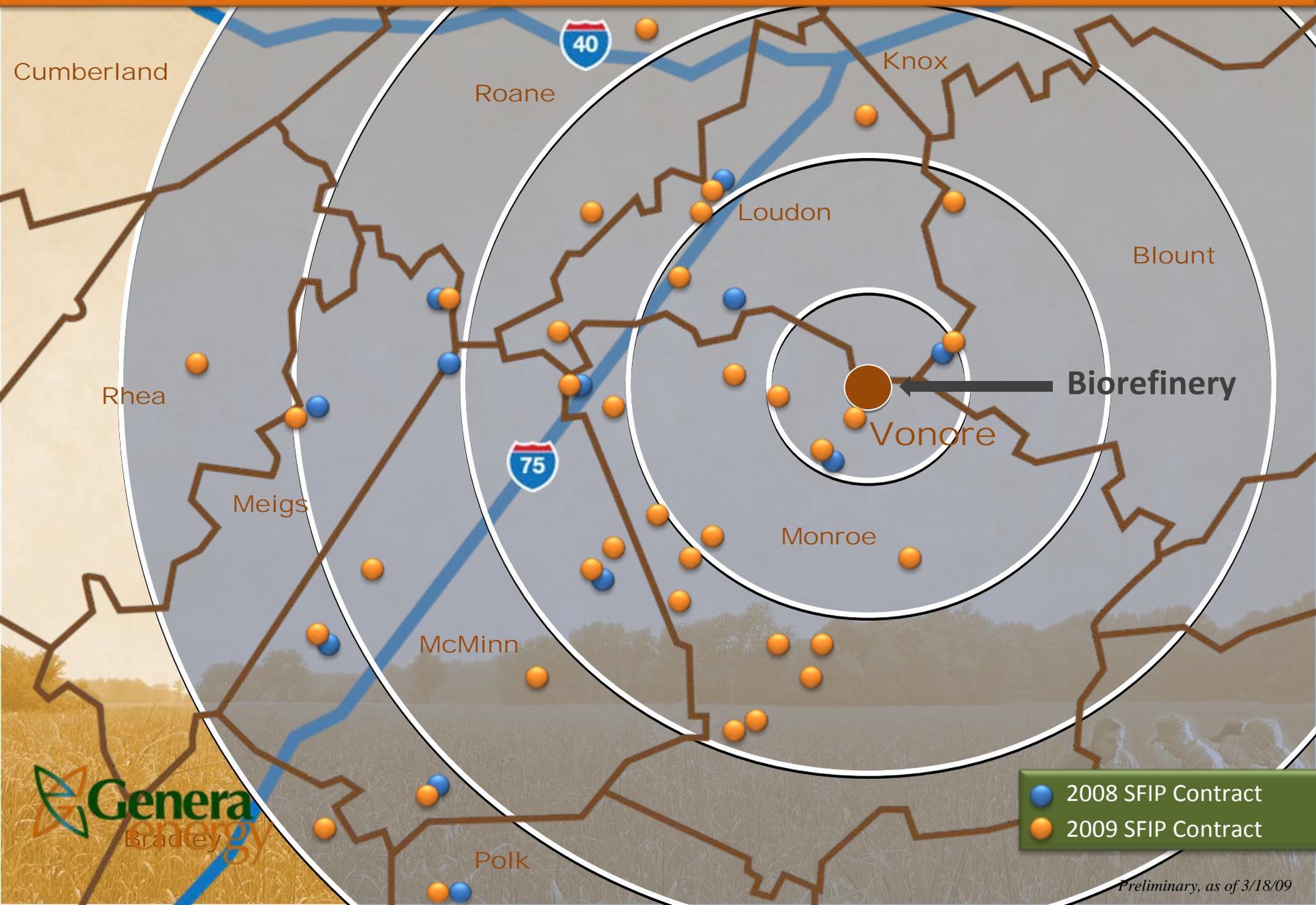


# Tenn. Switchgrass Experience (cont'd)

- Switchgrass program includes R&D on entire biomass supply chain
  - Farm production, harvest, densification, storage, transport, pre-processing
- Large research canvas
  - Evaluating soil carbon, improved varieties, harvest methods, storage, ecological impacts
- Building infrastructure for commercial supplies
  - Formed new-generation farmer cooperative to supply commercial partners



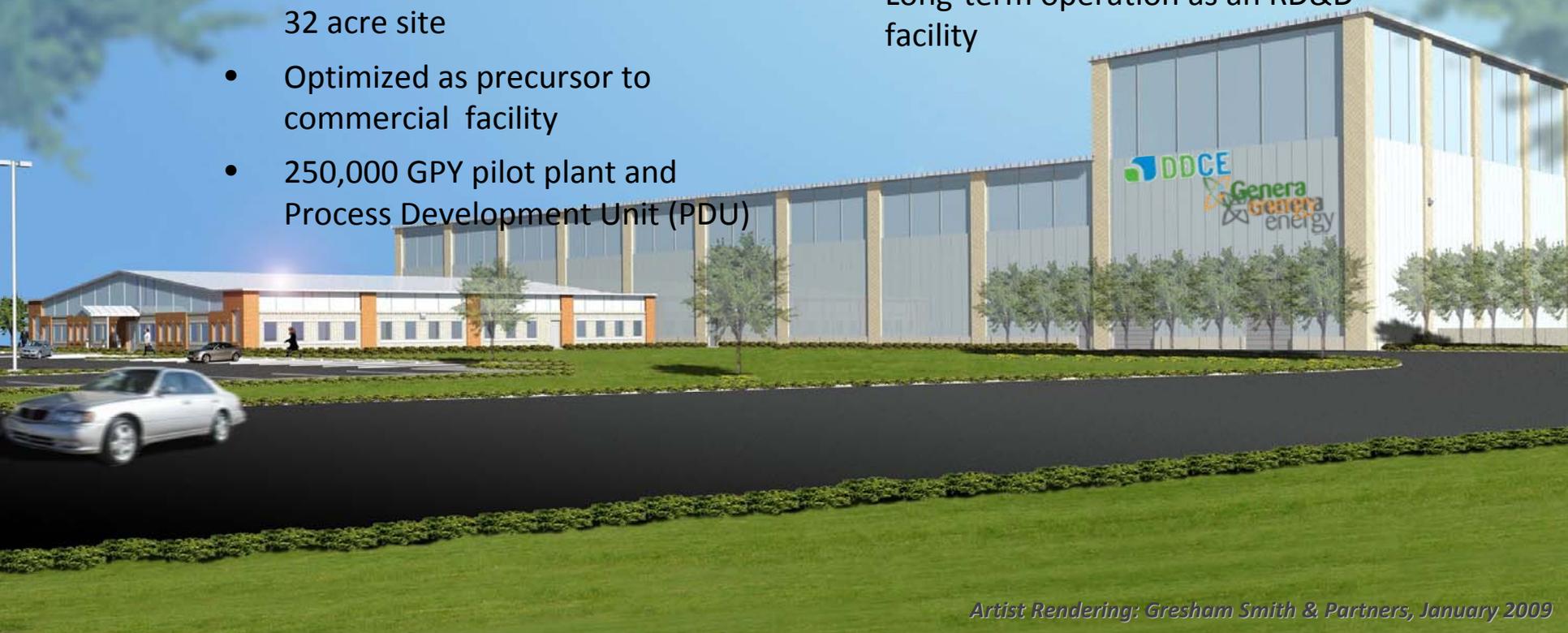
# Switchgrass Contract Farms



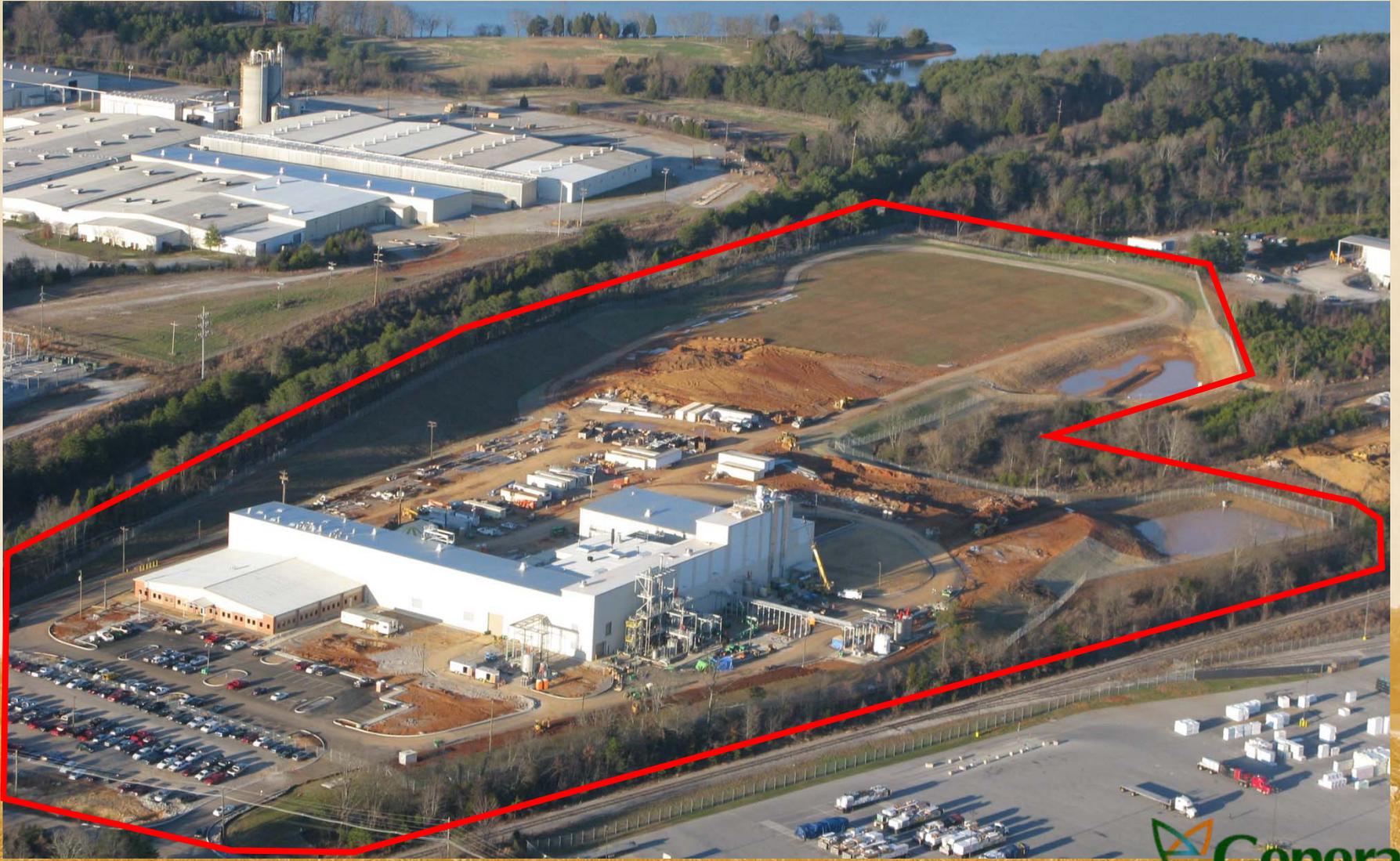
- 2008 SFIP Contract
- 2009 SFIP Contract

# Cellulosic Ethanol Biorefinery

- Collaboration between Genera Energy and DuPont Danisco (DDCE)
- Vonore, Tennessee: Niles Ferry Industrial Park, Monroe County, 32 acre site
- Optimized as precursor to commercial facility
- 250,000 GPY pilot plant and Process Development Unit (PDU)
- Started operations December 2009
- Multiple feedstocks: cob & switchgrass
- Long-term operation as an RD&D facility



2008 Jul Aug Sep Oct Nov Dec 2009 Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec 2010



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January 29, 2010

# Biorefinery Grand Opening



*"I believe the Vonore facility is going to be a real catalyst for additional economic activity in Tennessee. This marks an important step forward in our state's efforts to develop clean energy technology."*

**- Governor Bredesen**



# Biomass Processing & 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



# 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

# Biomass Energy Supply Chain

**Biomass Feedstocks**



**Biomass Logistics**



**Biomass Pre-Processing**



**Biomass Conversion**



**Product Logistics**



**End Use**



## Next Steps:

# Tennessee Biomass Innovation Park

- World-class research, development and demonstration campus
- Focused on purpose-grown energy crops such as perennial grasses, annuals, and short rotation woody crops
- Integrates entire biomass supply chain
  - Agronomics, plant genetics, production
  - Harvest, handling, storage, densification, transportation
  - High throughput screening and analysis
  - Pre-processing
  - Intermediate processing and conversion
- Co-located with biorefinery in Vonore



# Biomass Productivity R&D

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

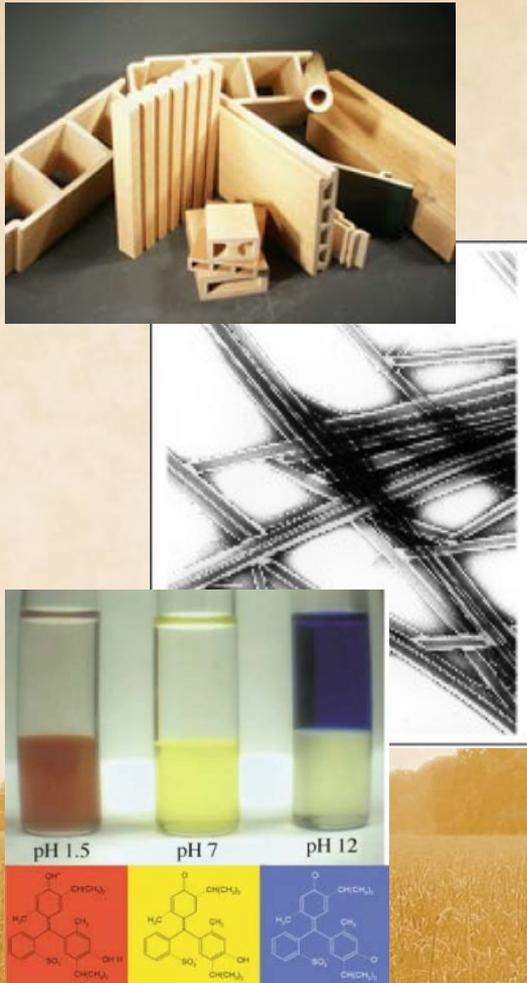


# “Bioengineering” R&D

Lots of opportunity for improving supply chain efficiencies



# 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

# Switchgrass Utilization Demonstration

- High-density bulk handling
- Switchgrass pelleting
- Switchgrass gasification demonstration
- Switchgrass torrefaction
- Co-firing demonstration (with coal)
- Fast pyrolysis
- Multi-feedstock systems



# Integrated Feedstock 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
- Pretreatment, separations



# Tennessee Leading by Example



[www.GeneraEnergy.net](http://www.GeneraEnergy.net)

[www.UTbioenergy.org](http://www.UTbioenergy.org)



*Institute of Agriculture* ♦ *Office of Bioenergy Programs*

