

Growing a Future of Clean Renewable Energy



Tennessee Biofuels Production – An Integrated Approach

Tennessee Biofuels Initiative

RCAS Winter Meeting
February 7, 2011
Corpus Christi, TX



Tennessee's Comprehensive Approach



Energy Crop Supply Chain

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

UT AgResearch **UT** Extension



Biofuels, Bioproducts R&D

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



Commercialization

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



Cellulosic Ethanol Biorefinery

Demonstrate the pre-commercial production of ethanol from switchgrass



\$70.5 Million
State Commitment

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Switchgrass as an Energy Crop

- 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, 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
- UT research focus for 20+ years

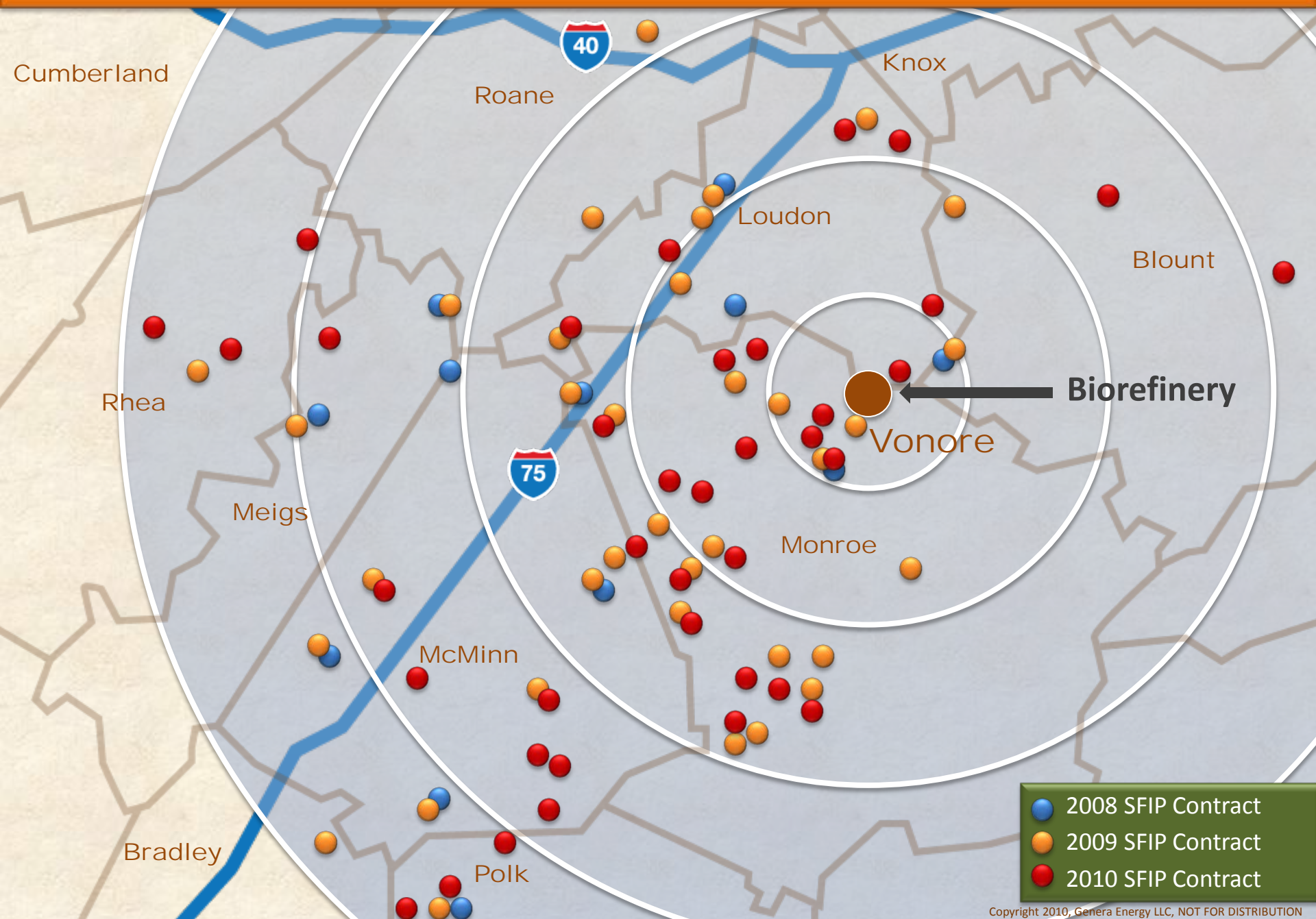


Tennessee Switchgrass Experience



- Contracting with local farmers to produce 6,000 acres of switchgrass
 - Nearly 3,000 acres harvested in 2009
 - Added >3,000 acres in 2010
 - 1,000 acres improved varieties
- UT/Genera contract with local farmers
 - ~\$450/ac/yr for 3 years
 - We provide seed, technical expertise
 - Separate storage contracts
 - Yield-based component in 2010
- Averaging about 8 tons/ac by 3rd year
 - Harvesting ~2 tons in year 1
 - ~5 tons in year 2
 - ~8 tons year 3 and beyond

Switchgrass Contract Farms



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- Coordinate R&D in renewable carbon systems
- Create new conversion technology
- Support technology demonstrations
- Educate and train the new workforce
- Transfer science and technology to a broad client base



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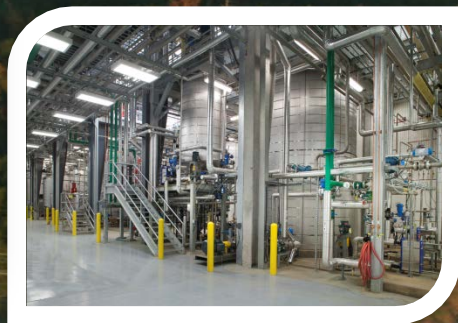
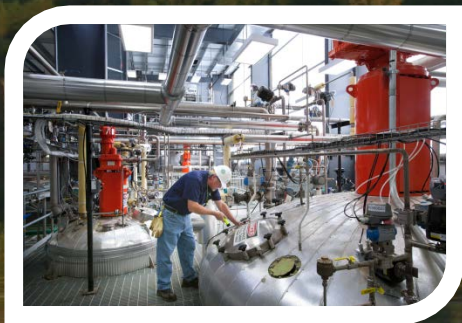
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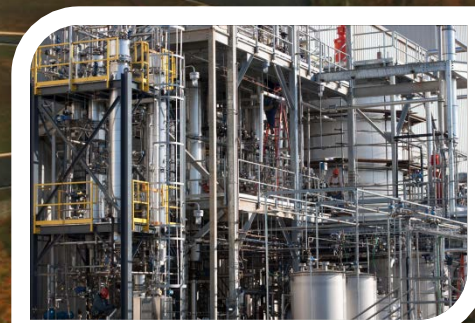


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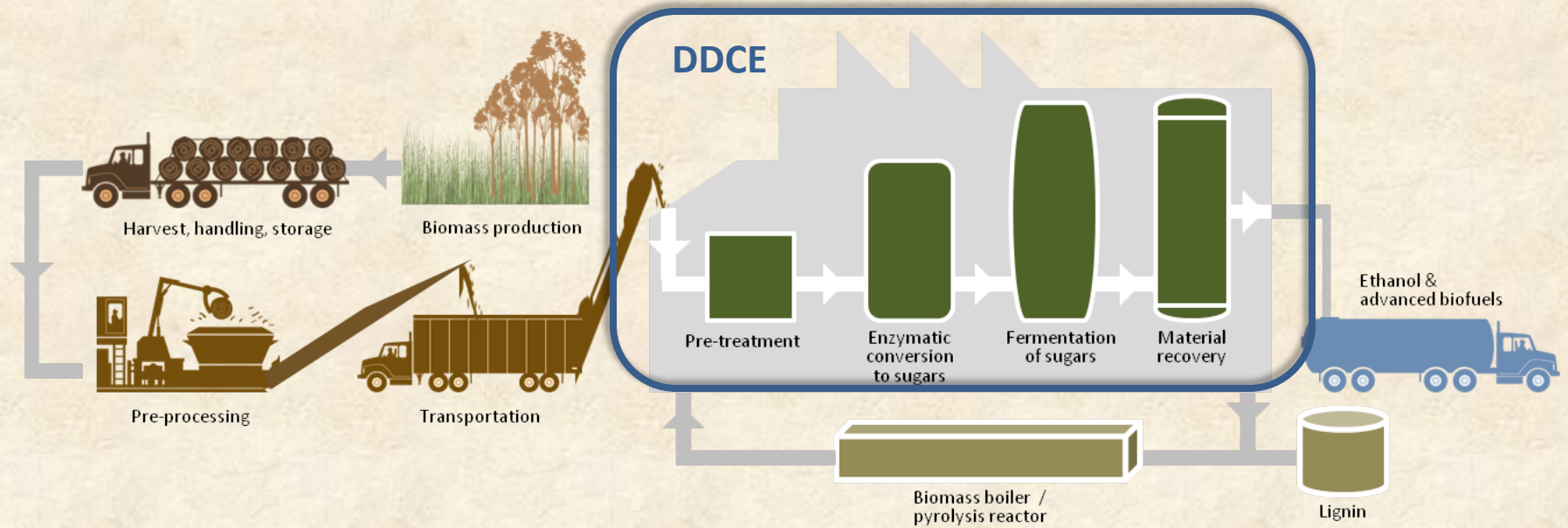
Cellulosic Ethanol Biorefinery



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



DDCE Proprietary Conversion Technology



- Pre-processed (chopped & milled) biomass arrives at the biorefinery
- DuPont-developed pre-treatment technology opens the polymers for greater enzyme access
- During enzymatic hydrolysis (or saccharification), Genencor-developed enzymes break down cellulose and hemicellulose into component sugars
- DuPont-developed fermentation technology converts sugars to alcohol
- Alcohol is distilled into fuel-grade ethanol & co-products are recovered
- Lignin can be burned for energy or used for other chemical and material products

Demonstration-Scale Biorefinery



Demonstration-Scale Biorefinery



Demonstration-Scale Biorefinery



World Class Lab Facilities



Training a New Industry Workforce



Technology Status & Key Indicators

- Feedstock cost (prior to entering conversion process) is >50% of total cost
- Enzymes are the most significant processing cost
 - Recent advances have reduced costs >50%
- Currently, ~85 gallons ethanol/dt biomass
 - Target is 100 gallons/ton
 - Converting both C5 & C6 sugars
- Biorefineries are capital intensive, ~\$6 per installed gallon
 - Target is \$4/gallon
 - At 50 MGY, capital cost is \$200-\$300 M
- Cost of manufacturing currently ~\$2/gal
 - Target is \$1.50, competitive with crude oil at \$75/bbl, without subsidies



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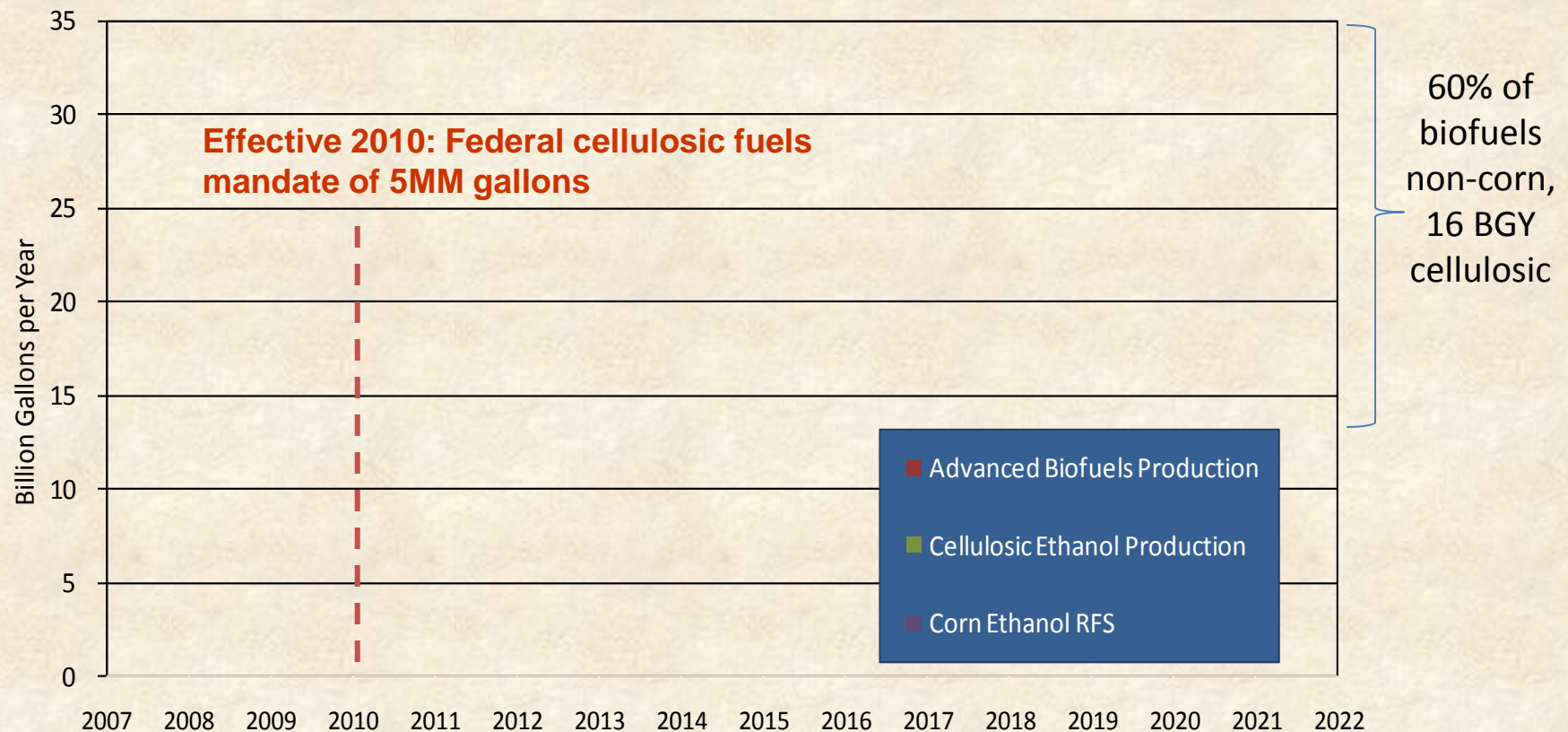
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Expanded Renewable Fuels Mandate



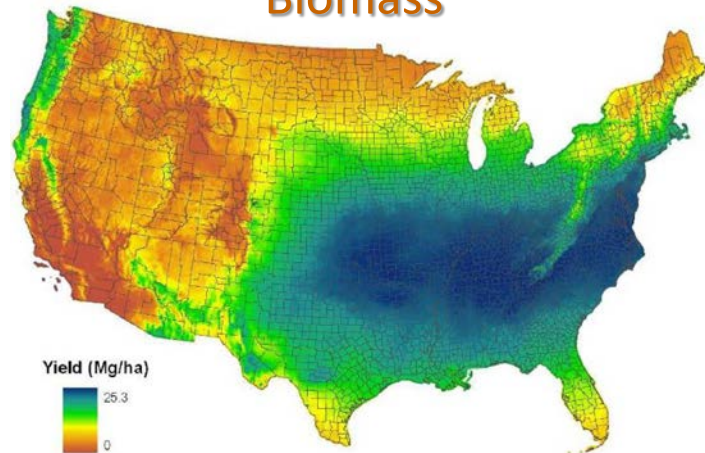
Market Opportunity

- 21 billion gallons of advanced biofuels required by 2022 to meet the RFS2 requirements (16 billion from biomass)
- Per USDA Biofuels Roadmap (June 23, 2010):
 - Majority of cellulosic biofuels will be from purpose grown energy crops (13.4 billion gallons)
 - Southeast will contribute half of total industry (49.8%)
 - Significant capital investment required to meet mandates (\$83.8 billion to build 263 biorefineries in the Southeast)
- Biomass also has comparative advantage for providing renewable electricity in the Southeast
 - While SE does not currently have state Renewable Electricity Standard (RES) mandates, potential for new federal mandates
 - Federal RES would put SE at a disadvantage due to dependence on coal

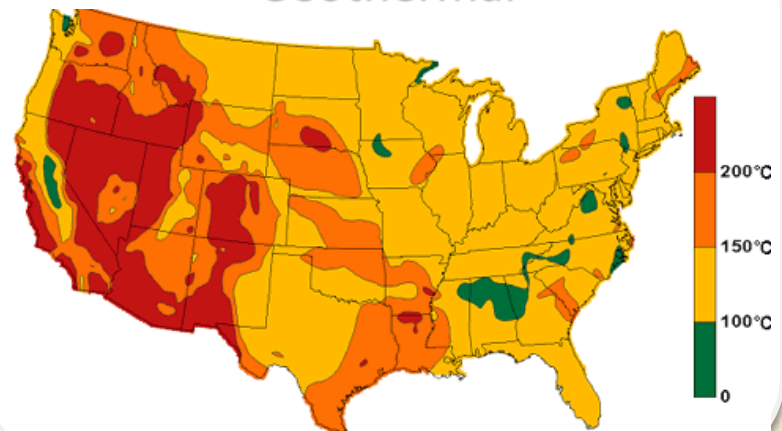


Renewable Energy Options

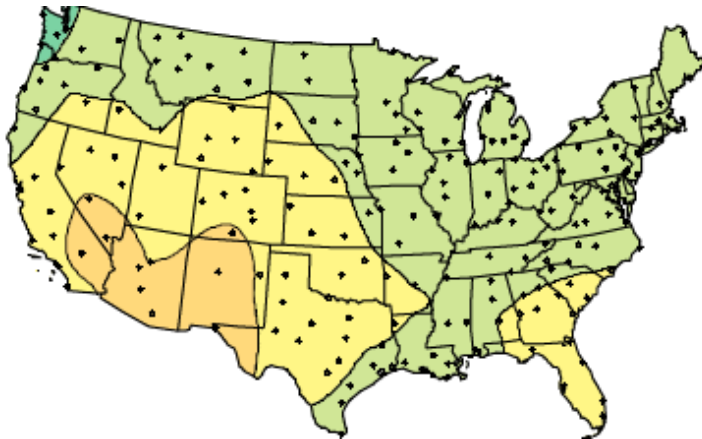
Biomass



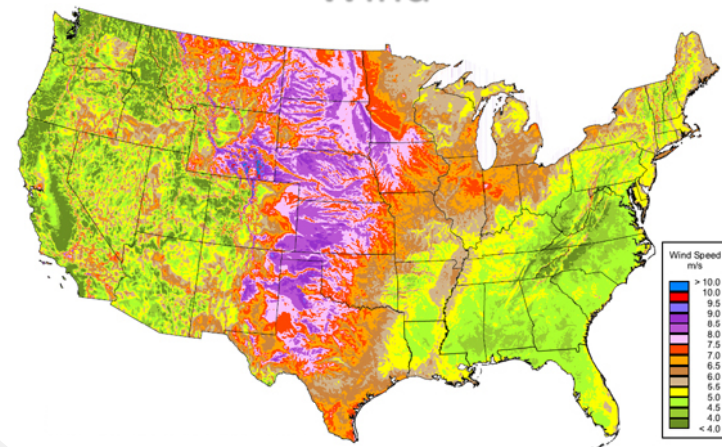
Geothermal



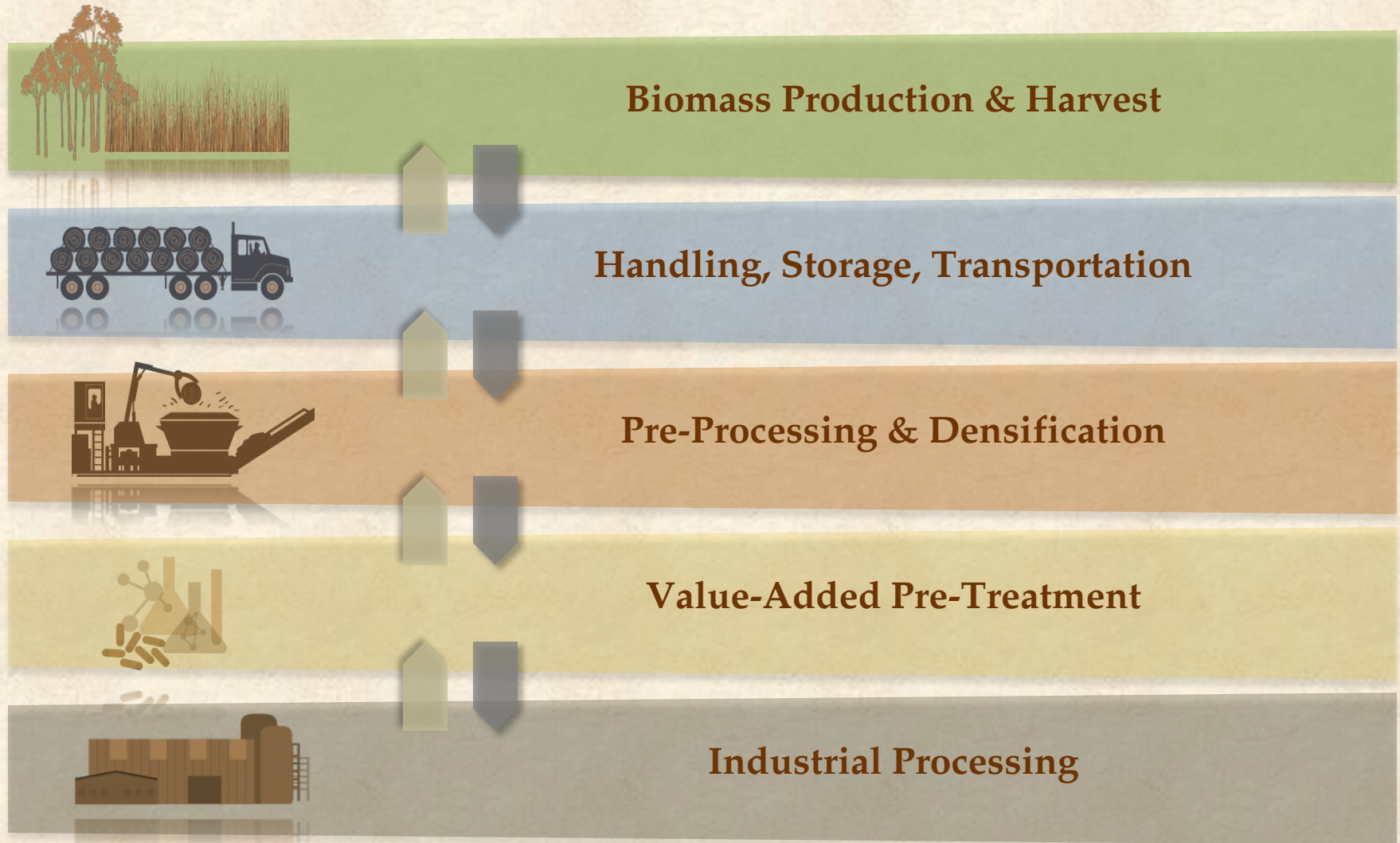
Solar (PV)



Wind



Integrated Biomass Supply Chain



Biomass Production & Harvesting



- Crop genetics
- Improved establishment
- Technical expertise
- Tailored equipment
- Seed availability
- Risk management




Genera
energy crops

Biomass Handling, Storage & Transportation



- Year-round supply
- Minimize handling
- Maximize bulk handling
- Minimize storage loss
- Maintain quality
- Manage moisture
- Increase bulk density



Biomass Pre-Processing



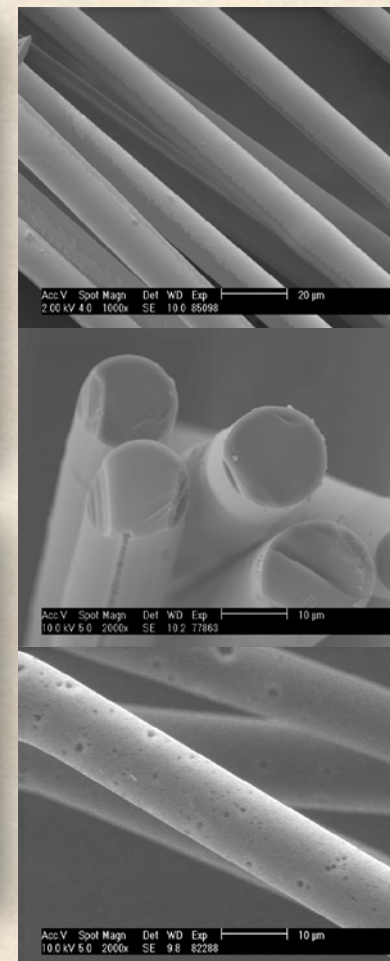
- Particle size – coarse chop to flour
- Conveyance & flowability
- Energy intensity
- New systems, systems integration
- Multiple feedstocks
- Packaging & transportation



Value-Added Pre-Treatment



- Better tailor feedstock to downstream conversion process
- Improve handling efficiencies
- Improve energy balance
- Use same feedstock to supply multiple markets
- Reduce storage requirements, costs



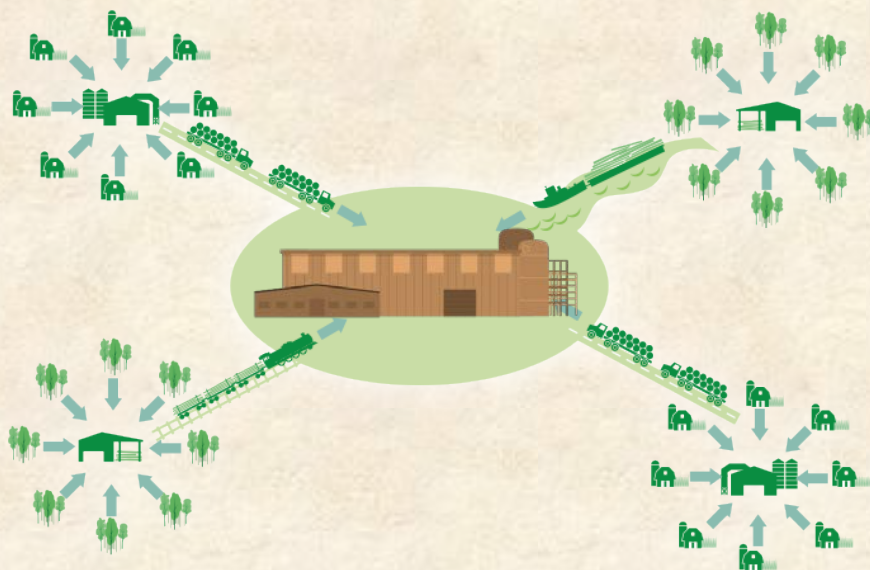
Tennessee Biomass Innovation Park

- World-class RD&D campus
- Integrates entire biomass supply chain
 - Harvest, handling, storage, densification, logistics
 - Pre-processing
 - High throughput screening and analysis
 - Agronomics, plant genetics, production
 - Intermediate processing and conversion
- Multiple feedstocks
- Site for \$5M DOE-funded high tonnage bulk handling demonstration
- Operational by end of 2010
- Strategic partnership opportunities
- Template for regional biomass depots



Depot Products for Downstream Conversion

Biomass Depot (hub and spoke) model for supplying, storing, and pre-processing biomass feedstock integrates well with Genera's



New Generation Processing Cooperative (federated cooperative model) for organizing and aggregating biomass and retaining value closer to the farm gate



Tennessee Leading by Example



www.GeneraEnergy.net
www.UTbioenergy.org



Institute of Agriculture ♦ Office of Bioenergy Programs

