Southern US Wood Bio-energy

- Demand is driven by:
  - EU
    - Kyoto and post-Kyoto carbon concerns
    - Aging nuclear and coal electricity facilities
    - Replace all of Germany’s nuclear plants by 2022
    - Renewable fuel aspirations
  - US
    - Mandates on renewable fuels. State imposed, not federal
    - Reduction of oil imports
    - Financial returns
EU 27 Bio-energy Demand by 2020

- Renewable Energy Directive
  - 20% reduction in GHG from 1990 levels
  - 20% energy efficiency improvements
  - 20% energy from renewable sources
  - 10% increase in bio-fuels usage

EU Demand 2020

- 130 million tonnes

- UK 20% renewables
  - 22 million tonnes wood pellets
  - 24-36 wood pellet facilities (1/3 in US South?)
  - First wood pellet exports from US South in 2005
UK Renewable Energy 2020 Targets

• 20% of energy needs from renewable sources
• 75% of renewables as wind, solar…
• 25% of renewables as biomass
• 50,000,000 dry tonnes biomass total
• 20,000,000 dry tonnes biomass-domestic
  • UK Forestry Commission says 2 million tonnes by 2020 in energy plantations
UK Wood Bio-energy

- FAO 2011  2,219,000 ha plantations
- 2009 Harvest  4,500,000 dry tonnes
- 2020 Demand  20,000,000 dry tonnes/year domestic

- 10 year rotation
  - MAI 3 dry tonnes/ha/year  6,667,000 ha
  - MAI 6 dry tonnes/ha/year  3,333,000 ha
US Renewable Energy in 2011

- 2.245 quadrillion BTUs
- 11.73% total US energy production
  - 49% biomass/biofuel
  - 35% hydro power
  - 13% wind
  - 2% geothermal
  - 1% solar
  (Nuclear 6.08% total US energy production)
  (US domestic oil 15.43% total US energy production)
US Renewable Energy Policy

- USDA + DOE vs EPA
- Congress vs President
- Big Oil Lobby vs. Renewable Energy
- Big Coal vs RFS
- Natural gas + Fracking = Low Cost + Low GHG
- WSJ article (August 2011) on SEC investigation of Fracking

- No policy is expected.
US Wood Bio-energy

- Current demand 36,000,000 green tonnes/year
- By 2021, 64% bio-energy wood for electricity
- 451 operating and announced bio-energy facilities.
- 189 operational, 35 under construction.
  - Cellulosic ethanol
  - Pellets
  - Electricity/co-generation CHP
  - US South every 1% co-gen requires 11 million tonnes wood
## Energy Values(1) of Biomass Feedstock Resources South and US(2)

<table>
<thead>
<tr>
<th>State</th>
<th>Bio-fuel</th>
<th>Forest</th>
<th>Crop, mill, urban</th>
<th>Biogas</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>3%</td>
<td>63%</td>
<td>33%</td>
<td>1%</td>
<td>289</td>
</tr>
<tr>
<td>AR</td>
<td>13%</td>
<td>41%</td>
<td>45%</td>
<td>1%</td>
<td>297</td>
</tr>
<tr>
<td>FL</td>
<td>1%</td>
<td>45%</td>
<td>51%</td>
<td>3%</td>
<td>196</td>
</tr>
<tr>
<td>GA</td>
<td>3%</td>
<td>64%</td>
<td>32%</td>
<td>1%</td>
<td>361</td>
</tr>
<tr>
<td>LA</td>
<td>10%</td>
<td>41%</td>
<td>49%</td>
<td>1%</td>
<td>246</td>
</tr>
<tr>
<td>MS</td>
<td>16%</td>
<td>64%</td>
<td>20%</td>
<td>1%</td>
<td>235</td>
</tr>
<tr>
<td>NC</td>
<td>9%</td>
<td>57%</td>
<td>32%</td>
<td>3%</td>
<td>308</td>
</tr>
<tr>
<td>SC</td>
<td>4%</td>
<td>71%</td>
<td>23%</td>
<td>1%</td>
<td>176</td>
</tr>
<tr>
<td>TN</td>
<td>14%</td>
<td>54%</td>
<td>30%</td>
<td>2%</td>
<td>177</td>
</tr>
<tr>
<td>VA</td>
<td>6%</td>
<td>63%</td>
<td>29%</td>
<td>2%</td>
<td>184</td>
</tr>
<tr>
<td>South Total</td>
<td>12%</td>
<td>50%</td>
<td>36%</td>
<td>2%</td>
<td>3,123</td>
</tr>
<tr>
<td>US Total</td>
<td>31%</td>
<td>33%</td>
<td>34%</td>
<td>2%</td>
<td>10,724</td>
</tr>
</tbody>
</table>

- (1) Trillion BTUs
- (2) USDA Forest Service, 2007.
US Ethanol for Bio-fuel

• Production started in 1980’s with oil embargo
• 1990’s low oil prices = low ethanol capital and research investment
• In 2011, E10, E15, E85

• In 2011, Replaces 10% of US automotive fuel
• Equal to imports from Saudi Arabia

• Source: Ethanol Producer Magazine 07/2011
Food vs. Fuel

<table>
<thead>
<tr>
<th>Year</th>
<th>Corn (billion bushels)</th>
<th>Food (%)</th>
<th>Fuel (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>5</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>1990</td>
<td>6</td>
<td>98</td>
<td>2</td>
</tr>
<tr>
<td>2000</td>
<td>7</td>
<td>95</td>
<td>5</td>
</tr>
<tr>
<td>2010</td>
<td>11</td>
<td>60</td>
<td>40</td>
</tr>
</tbody>
</table>

In 2010 with E10 going to E15

- US$0.45/gallon blenders tax credit
- US$0.54/gallon import tariff
- 6 billion bushels corn for foodsame as in 1985
US Cellulosic Ethanol

- Not working at commercial levels

- 2012 DOE goal 500 million gallons
- 2012 DOE reality 12.9 million gallons

- 2011 corn ETOH 12.9 billion gallons
- 2015 corn ETOH 15.0 billion gallons
Wood Bioenergy South
Project Annual Wood Demand 2021
www.forisk.com

<table>
<thead>
<tr>
<th>State Residues**</th>
<th>Projects</th>
<th>New Tons*</th>
<th>Current PW Tons*</th>
<th>Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>8</td>
<td>4,947,460</td>
<td>22,319,461</td>
<td>5,100,000</td>
</tr>
<tr>
<td>AR</td>
<td>7</td>
<td>1,820,000</td>
<td>8,599,960</td>
<td></td>
</tr>
<tr>
<td>FL</td>
<td>18</td>
<td>10,574,125</td>
<td>8,810,364</td>
<td>4,700,000</td>
</tr>
<tr>
<td>GA</td>
<td>36</td>
<td>18,167,578</td>
<td>24,910,968</td>
<td></td>
</tr>
<tr>
<td>LA</td>
<td>4</td>
<td>3,300,000</td>
<td>13,202,538</td>
<td></td>
</tr>
<tr>
<td>MS</td>
<td>8</td>
<td>3,183,239</td>
<td>9,756,782</td>
<td>3,320,000</td>
</tr>
<tr>
<td>NC</td>
<td>13</td>
<td>2,796,000</td>
<td>6,516,913</td>
<td>3,617,000</td>
</tr>
<tr>
<td>SC</td>
<td>11</td>
<td>2,939,800</td>
<td>11,754,290</td>
<td>3,700,000</td>
</tr>
<tr>
<td>TN</td>
<td>6</td>
<td>3,150,000</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>TX</td>
<td>9</td>
<td>2,862,440</td>
<td>8,828,168</td>
<td></td>
</tr>
<tr>
<td>VA</td>
<td>15</td>
<td>2,207,300</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>147</strong></td>
<td><strong>64,812,537</strong></td>
<td><strong>125,294,759</strong></td>
<td></td>
</tr>
</tbody>
</table>

* Green tons
** Green tons estimated as available by state agency or USFS
Post Harvest Residue
Gadsden Co. Florida

Whole Tree Chipped

Conventional Tree Length Harvest

Bio-energy Availability = Zero on Many Logged Sites
Bio-energy Resources (?)

Urban waste

Logging site waste
Annual Forest Residues, 1994-2008

Kentucky

Final Harvest (acres) 16,600
• Partial Harvest (acres) 255,300
• Thinning (acres) 10,700
• Total (acres) 282,600
• Recoverable, merchantable
• Logging Residues (tons) 2,261,579
• Tons/acre 8.0

• Source: Conner & Johnson, USDA Forest Service SRS-169, 01/2011
South Carolina Annual Logging Residues 2001-2006

Total harvest 35.7 million tons
Residue harvest 7.8 million tons
Residue available 3.7 million tons

Logging Residue by Type

Recoverable 2.0 million tons/year
Harvest activities 412,000 acres/year

Source: Tim Adams
Resource Development Director
South Carolina Forestry Commission
November 2009
Cottonwood Plantation for two million tons/year
High Productivity Enables Reduced Biomass Transportation Costs

- A processor consuming 1 million dry tons of biomass from forest residues could require nearly 60 mile radius to support it
- Productivity improvements can reduce land area needs by more than 90%

Assumptions:
- 1 million dry tons/year consumption
- 15% land utilization
Biomass delivered cost for each of the feedstock, considering 5% covered area and annual supply of 453,597 dry ton year$^{-1}$
There are a range of hardwood species for fiber, bio-energy and bio-fuel use in the S.E. USA

- Eucalyptus
- Eastern Cottonwood
- Hybrid Poplar
- Sweetgum
- Hybrid Aspen
Eastern Cottonwood

Large ECW germplasm collections for deployment in the SE USA

Uses: High quality hardwood pulp & potential for furniture lumber

Productivity: ECW is the fastest growing eastern USA hardwood—3-20 Gtons/ac/yr in a pulpwood 10 yr rotation
Site: Eastern USA
Soils: Moderately well drained uplands to alluvial bottomlands—not poorly drained
Site constraints are much greater than for Sweetgum or pine
Silviculture is well defined for establishing ECW—Understanding of resource requirements to grow ECW on upland moderately well drain soils could be improved
Resource inputs to establish & grow are high
Resource requirements are greater for ECW than SG.

9-year-old Eastern Cottonwood on moderately well drained soil in Columbus County, NC
## Cottonwood and Hybrid Poplar Yields
*(green tons/acre/year)*

<table>
<thead>
<tr>
<th>Site</th>
<th>Age (years)</th>
<th>Irrigated</th>
<th>Non-Irrigated</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR Delta</td>
<td>5</td>
<td>8.6</td>
<td>4.2</td>
<td>Stuhlinger 2008</td>
</tr>
<tr>
<td>AR Delta</td>
<td>10</td>
<td>4.6-6.8</td>
<td>1.4-3.0</td>
<td>Stuhlinger 2007</td>
</tr>
<tr>
<td>LA fiber farm</td>
<td>7</td>
<td>22</td>
<td>17</td>
<td>Donahue 2009</td>
</tr>
<tr>
<td>KY fiber farm</td>
<td>8</td>
<td>13-15</td>
<td>-</td>
<td>Rousseau 2009</td>
</tr>
<tr>
<td>SE US</td>
<td>5-8</td>
<td>-</td>
<td>4.2-9.3</td>
<td>NCSU 1994</td>
</tr>
<tr>
<td>SE US</td>
<td>9-12</td>
<td>-</td>
<td>5.5-10.6</td>
<td>NCSU 1994</td>
</tr>
<tr>
<td>Sharkey Co MS</td>
<td>10</td>
<td>-</td>
<td>5.4</td>
<td>Lockhart 2009</td>
</tr>
<tr>
<td>Florida</td>
<td>10</td>
<td>15-20</td>
<td>-</td>
<td>Rockwood 2009</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td><strong>5-12</strong></td>
<td><strong>4.6-22</strong></td>
<td><strong>1.4-17</strong></td>
<td></td>
</tr>
</tbody>
</table>
Two Year Old Hybrid Poplar

Randolph AL

Allendale SC
Sweetgum

Large SG germplasm pool

Uses: Hardwood pulp, lumber and biomass for energy
Species: Liquidambar styraciflua
Site: SE USA – Similar to loblolly
Soils: Poorly to well drained soils
SG is the native hardwood with the broadest deployment potential in the SE USA.
Productivity range: 6-10 Gtons/ac/yr
-Silvicultural regimes for establishing and growing SG are well understood and practical
Improvements: Hybrids with Korean SG

14-year-old Sweetgum plantation on Powell Bay Unit-Berkeley County, SC—9Gtons/ac/yr
Varietal yield improvements from 2nd generation selections

Projected yields based on 8 year genetic test data of unimproved and 1st generation seedlings and a selected 2nd generation varietal planted on sites in VA, NC and SC.
Comparison of mean annual yield increment for non-fertilized and fertilized sweetgum

Mean Annual Increment at Age 15 for Non-Fertilized and Fertilized Sweetgum Plantations

at 3 Sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Year</th>
<th>Mean Annual Increment - Round wood</th>
<th>Mean Annual Increment - Total tree chips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Featherbed</td>
<td>100N, 25P Year 2</td>
<td>5.8</td>
<td>7.4</td>
</tr>
<tr>
<td>Featherbed</td>
<td>100N, 25P Year 3</td>
<td>6.6</td>
<td>7.8</td>
</tr>
<tr>
<td>Burch</td>
<td>Control</td>
<td>6.9</td>
<td>8.8</td>
</tr>
<tr>
<td>Burch</td>
<td>100N, 50P Year 3</td>
<td>10.2</td>
<td>11.2</td>
</tr>
<tr>
<td>Jericho</td>
<td>Control</td>
<td>6.1</td>
<td>8.2</td>
</tr>
<tr>
<td>Jericho</td>
<td>100N, 50P Year 3</td>
<td>7.4</td>
<td>9.8</td>
</tr>
</tbody>
</table>
Diameter effects in sweetgum due to initial spacing

Mean DBH (in) at Ages 7 and 15 for 2 Sweetgum Plantations Planted at 4 Spacings

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Age 7</th>
<th>Age 15</th>
<th>O'Bryan</th>
<th>Slater</th>
</tr>
</thead>
<tbody>
<tr>
<td>6'x10'</td>
<td>4.2</td>
<td>7.0</td>
<td>4.6</td>
<td>6.6</td>
</tr>
<tr>
<td>8'x10'</td>
<td>4.8</td>
<td>8.1</td>
<td>4.8</td>
<td>7.2</td>
</tr>
<tr>
<td>10'x10'</td>
<td>5.2</td>
<td>8.8</td>
<td>5.2</td>
<td>3.7</td>
</tr>
<tr>
<td>12'x10'</td>
<td>7.0</td>
<td>9.6</td>
<td>7.0</td>
<td>4.1</td>
</tr>
</tbody>
</table>
Mean annual yield increment (total tree and round wood) in sweetgum due to initial spacing
Sweetgum Mean Annual Increment (green tons/acre/year) at Age 7 (actual) and Age 15 (predicted) at four Spacings Showing Average Diameter for each Spacing and Age
Hybrid Aspen *P. X canescens* (*alba x tremula*)

Capturing more than 100 hybrid aspen clones

Hybrid Aspen has greater application at higher latitudes in the eastern USA than cottonwood.

11 year-old hybrid aspen in VA
Hybrid Aspen In Bamberg, South Carolina

Age 1.5 year variety comparison

Age 2.5 year commercial plantation
Electricity Generation from Forest Plantations
Tacuermbbo Uruguay
Bio-energy Analysis

Field Crew – Brute Force

Lab Crew – Intelligent Force
Eucalypts for solid bio-energy production

Wood pellets and briquettes can be effectively manufactured from Eucalyptus

Pellets/briquettes from Eucalyptus provide optimized transportation of biomass

Pellets burn cleaner and more efficient, and are gaining recognition as a useful fuel for co-firing in coal plants

Wide variety of applications from residential heating to commercial energy generation, with a market projected to increase for the next 10 years
Stem Size Matters
Eucalypt Bio-energy Harvest

Plantation age 18 months
Harvesting Systems
Mountain Top Coal Mining
Harvesting Systems?
Adequate for Agriculture and Forest Harvesting
Bio-energy Plantations on Reclaimed Mine Lands

Robinia pseudoacacia

Populus deltoides

740,000 acres in Kentucky
Bio-energy Plantations are Achievable

- Where do we take this?
- Species trials
- Clonal trials
- Wood testing for bio-energy
- Silviculture needs
Questions?

Jeff Wright
843 991 2911

Coltrane