

## Biomass Power Options

### *Biomass Co-firing Approaches*

1. **Direct injection** – Introduce ground biomass pneumatically into the boiler through dedicated burners (10 to 20% energy input basis)
2. **Co-milling** – Mix biomass with coal and introduce into the boiler through the coal handling system (3 to 5% energy input basis)



## Biomass Co-firing

### *Advantages and Disadvantages*

#### **Advantages:**

- Lower capital cost
- Emissions reductions
- Customer

#### **Disadvantages:**

- Lower energy density
- Compatibility with pulverized coal feed systems
- Cost



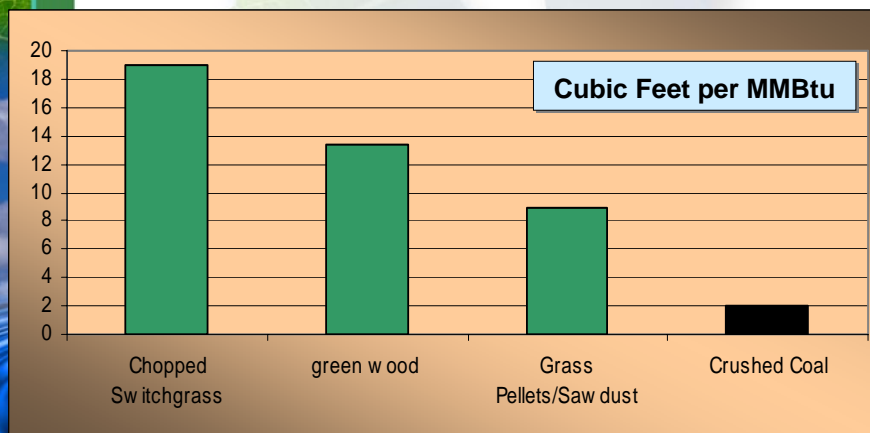
## Biomass Co-firing

### *Fuel Types Tested*

- Ground switchgrass
- Sawdust
- Wood chips (nominally 1 inch plus)
- “Small” wood chips (nominally ½ inch or less)



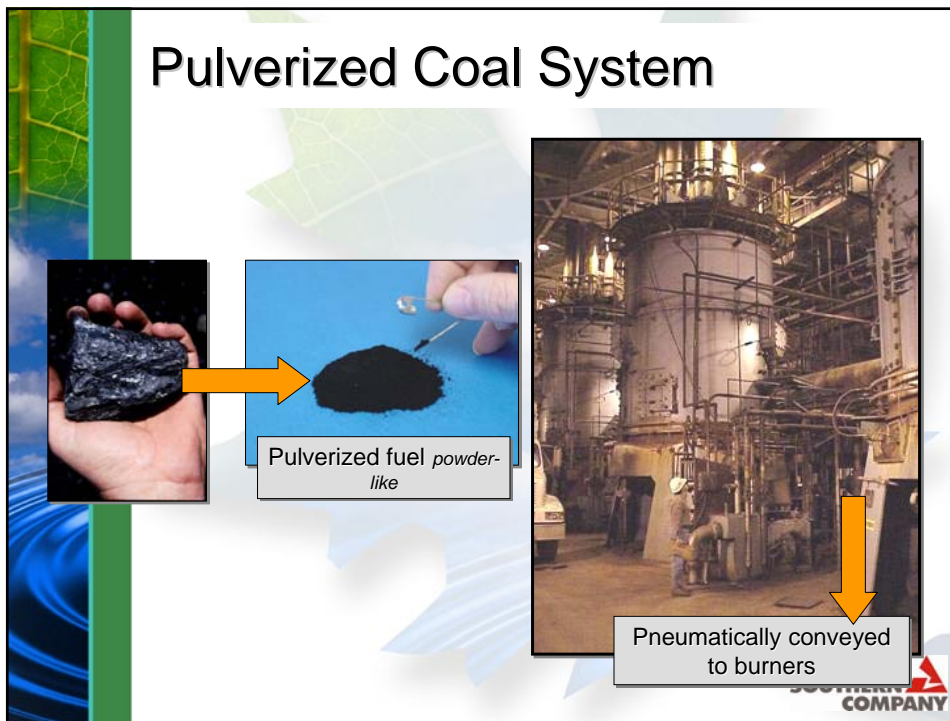
## Low Volumetric Energy Density for Biomass Increases Handling and Transport Costs



## Biomass versus Coal

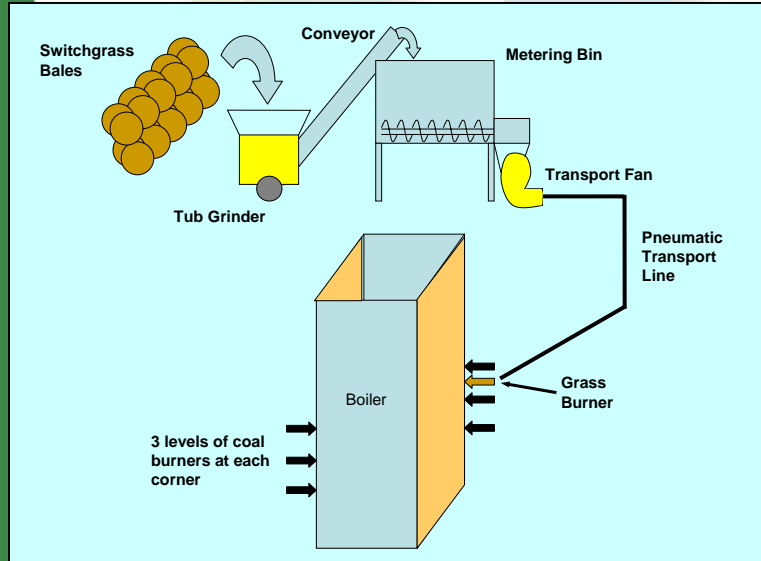
| Component<br>(as received) | Sawdust<br>(Hickory) | Switchgrass<br>(Alamo) | Coal<br>(Bituminous) |
|----------------------------|----------------------|------------------------|----------------------|
| Heating Value<br>(Btu/lb)  | 5,399                | 7,380                  | 12,053               |
| Moisture (%)               | 35.14                | 12.18                  | 6.04                 |
| Ash (%)                    | 0.71                 | 5.33                   | 13.17                |
| Sulfur (%)                 | 0.01                 | 0.13                   | 1.92                 |
| Nitrogen (%)               | 0.12                 | 1.17                   | 1.42                 |

## Pulverized Coal System



# Switchgrass Direct Injection

## *Simplified Schematic*



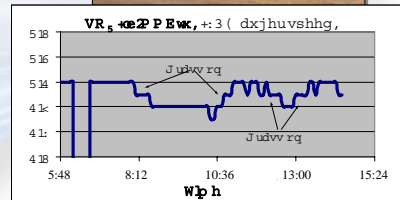
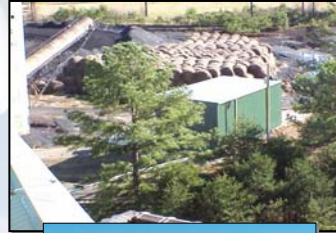
# Switchgrass Grinding Facility



## Switchgrass Direct Injection at Plant Gadsden

### *Basic Operating Facts*

- Support for RE pricing program and R&D tests
- Began operation in 2001
- Co-firing range 5 to 10%
- Lower SO<sub>2</sub> emissions
- About 500 tons of switchgrass per year (200 hours --- 1<sup>st</sup> shift)



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## Biomass Power Options

### *Biomass Co-milling*

- Co-milling (Plant Gadsden Unit 1)
  - Sawdust
  - Wood chips



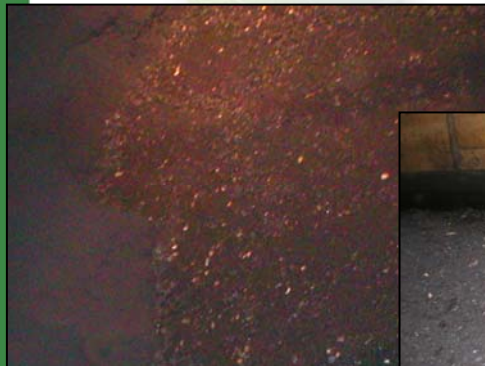
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## Unloading Sawdust at Gadsden



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## Good Mixing Achieved



**Bunker**



**Belt**

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## Long Fibers



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## Long Fibers Trapped In Riffles



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## Small Wood Chips Co-milling



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## Small Wood Chips Co-milling



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## Small Wood Chips Co-milling



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## Small Wood Chips Co-milling



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## Small Wood Chips Co-Firing



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## Small Wood Chips Co-milling



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## Small Wood Chips Co-milling



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## Small Wood Chips Co-milling



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## Biomass Power Options

### *Biomass Co-firing Summary*

- Switchgrass direct injection successful
- Sawdust co-milling successful
- Wood chip co-milling plugged pulverizers
- “Small” wood chip co-milling successful



## Biomass Co-Firing

### *Remaining Technical Issues*

- Effect of biomass minerals on NO<sub>x</sub> control devices → SCR (Selective Catalytic Reduction) units
- Current ASTM specifications exclude biomass ash-coal ash mixtures for cement



*Questions ?*

