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Air Pollution Control Systems for Biomass Boilers

Biomass South 2008

September 21-23, 2008
Raleigh Convention Center
Raleigh, NC

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- Danvers, MA based supplier of APC systems, boilers, heat exchangers, HRSG
- Largest supplier of NO_X SCR systems in the US
- Babcock Power 2007 Sales ~$1B
  - Includes Power Services (“Riley Stoker”)
  - Leading supplier of biomass and WTE boilers
    - Thirty-two biomass boilers
    - 60,000 to > 500,000 lb/hr steam
    - Pressures to 1500 PSIG

Developer of the RSCR Technology

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Topics

- Biomass market trends and drivers
- Overview of biomass and coal fired boiler emissions
- Control technologies
  - NOx, SO_2, CO, PM
  - Biomass emissions with controls
- Co-firing overview
- Summary

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Renewable Energy and Biomass

- Biomass energy:
  - Renewable energy
  - Sustainable fuel supply
  - Significant power generation (15 to 100+MW)
  - Power is generated day or night; wind or not
  - CO_2 neutral or better
  - Proven, reliable, economical
  - Key negative factor is *emissions*

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Biomass Issues

Emissions - the Primary Concern

Pollutant	Emissions
• SO_2	Very Low
• HCl	Very Low
• Hg	Very Low
• PM	Low
• CO	Moderate
• NOx	Moderate/High

NOx and CO are main pollutants

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Uncontrolled Emissions

(lb/MBtu)	Coal	Biomass
	Uncontrolled	*Uncontrolled*
NOx	0.32 to >1.5	0.15 to 0.48
SO2	0.8 to >6.0	<0.08
CO	0.04 to 0.15	0.15 to 0.45
PM	3 to 15	0.2 to >1.0

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Incentives for New Biomass Power Units

- Power sales
- RECs
- Production tax credit
  - Renewal?
  - Parity?
- Public benefit funds
- Tax incentives
- Emissions allowance trading
- CO_2 allowances?

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Biomass Applications – RECs

- **New England RPS Programs require low NO_X emissions to qualify for Class 1 RECs**
  - CT requires 0.075 lb/MBtu (>$50/REC)
  - MA, NH require 0.065 lb/MBtu (>$50/REC)
- **Most other states allow biomass in the RPS**
  - **AQC agency sets emissions limits**
  - **Lower prices than New England ($20- 50/MWh)**

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Biomass Power Boiler - Trends

- **Stokers**
  - Largest installed base
  - Fuel flexible
  - Proven, reliable, improved
- **Bubbling/fluidized bed**
  - Fuel flexible
  - In-situ SO_2 control (not req'd for biomass)
  - Somewhat lower uncontrolled emissions
  - High parasitic load
- **Gasifiers**
  - Relatively small scale
  - Typically combust "syngas" from gasifier

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Biomass Emissions Control Technologies

Particulate Matter

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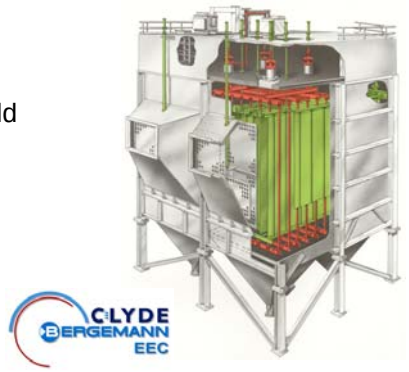
Electrostatic Precipitator (ESP)

– Device that removes wet or dry suspended matter from combustion or process gas streams through an electrostatic process:
  - Gas Ionization
  - Particulate Charging
  - Influence of Electric Field



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Electrostatic Precipitator

- High Efficiency Particulate Control Device
  – Controls emissions down to 0.01 lbs/MBtu (20-30 mg/Nm^3)
- Applicable to a wide variety of fuels and boiler types
  – WTC, urban waste
  – Stoker, CFB, BFB
- Size of ESP is a Function of Particle Characteristics & Gas Conditions

Typical ESP

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Electrostatic Precipitators

Advantages

- Very Low Pressure Drop (< 0.75 inches wc)
- High Collection Efficiency (> 99.5% is possible)
- Applied to a wide variety of Power and Industrial Applications
- Able to tolerate “sparklers” from biomass

Disadvantages

- Sensitive to Operating Conditions- Volume & Flue Gas Chemistry

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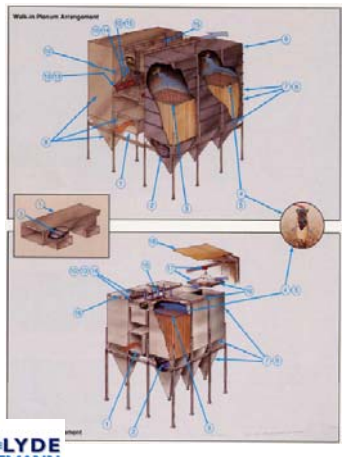
Fabric Filter

- Fabric Filter Systems (“Baghouses”)
  - A particulate laden gas stream passes through a fabric filter bag whereby the particulate is collected on the surface of the fabric.
- Major types:
  - Pulse-Jet Filters
    - Walk-in Plenum or Top Door
    - Tall Bag Designs
    - Low, Med, High Pressure
  - Reverse-Air Filters



CLYDE BERGEMANN EEC

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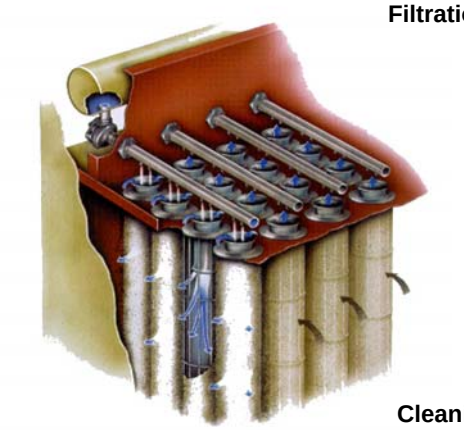
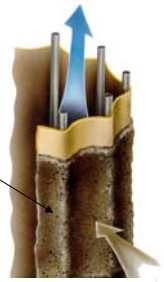
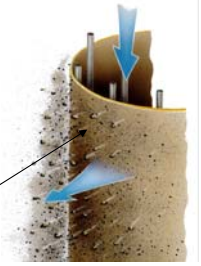
Fabric Filter

- 





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Fabric Filters

Advantages

- Constant Emission Control Device
  - Controls emissions to 0.01 lbs/MBtu (20-30 mg/Nm^3)
- Applicable to a wide variety of Fuels and boiler types
- Function of Particle Characteristics & Gas Conditions

Disadvantages

- High pressure drop (6” wg)
- Bags can burn, melt

Clyde Bergemann EEC Pulse-Jet Fabric Filter

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Emissions Control Technologies

NOx

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Options to Achieve Low NO_X for Biomass Boilers

- "Conventional" technologies – limited reduction (OFA/FGR)
- SNCR – moderate reduction
- Modified SNCR - limited/moderate reduction
  - Ceramic injection tubes/NH_3 injection
  - High pressure rotating OFA/NH_3 injection
- SCR – high reduction efficiency

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Selective Non-Catalytic Reduction (SNCR)

Introduction of Specific Nitrogenous Reagents at Specific Temperature Regimes to Effect a Reducing Reaction.

NOxOUT® Process Chemical Reaction

$$2NO + NH_2CONH_2 + \tfrac{1}{2}O_2 \Rightarrow 2N_2 + CO_2 + 2H_2O$$

NITROGEN OXIDE + UREA + OXYGEN ⇨ NITROGEN + CARBON DIOXIDE + WATER

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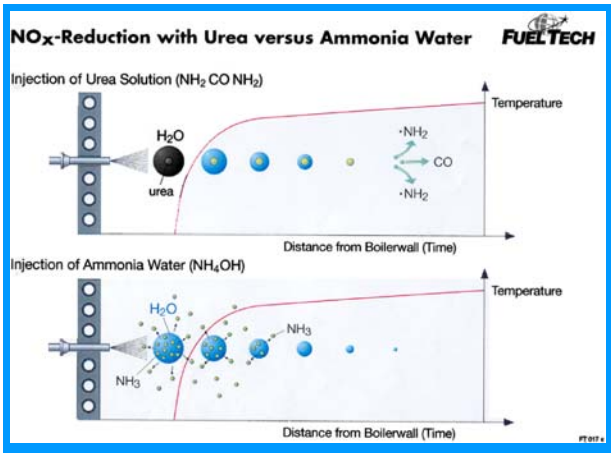
Critical SNCR Process Parameters

- **Temperature** – 1600°F to 2200°F (Process Dependent)
- **Residence Time** – 0.2 Seconds to 2.0 Seconds
- **Background Gas Composition** – CO, O_2, NOx
- **NOx Reduction** – Baseline and Target
- **Reagent Distribution** – Access and Penetration

Droplet Injection, Evaporation and Chemical Release



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SNCR Process

Advantages

- Independent of Fuel Type
- Easily Retrofit
- Tunable to Specific Reduction Needs
- Compatible with Other Combustion and Post-combustion NOx Reduction Processes
- Relatively Low Capital Cost
- Good biomass experience

Disadvantages

- High Chemical Cost
- Limited Removal Efficiency (to about 0.1 – 0.15 lb/MBtu)

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Regenerative Selective Catalytic Reduction (RSCR)

- New technology developed by BPE
- Development goal was high NOx reduction, high thermal efficiency, and low total cost for WFB, WTE, and industrial boilers
- US Patent # 7,294,321 issued 11/14/07
- Units successfully running for 4 years

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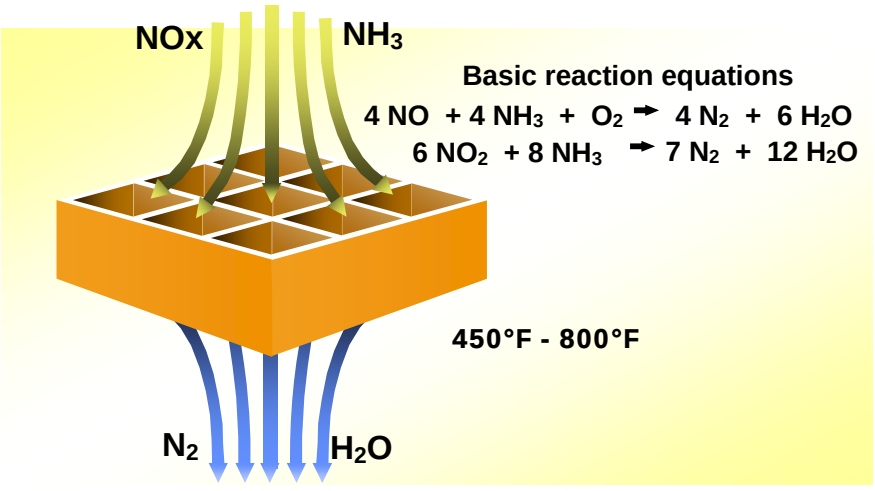
Chemistry of the SCR Process



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Biomass and WTE Applications

Initial consideration was for “conventional” SCR

- Poisons affect all SCR catalysts the same
  - Potassium, sodium, arsenic are irreversible
- High K/Na concentrations in wood ash preclude use of conventional SCR
- Heavy metals in WTE flue gas will poison catalyst – conventional SCR not possible

Requires the use of a “tail-end” SCR

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RSCR Design

- Tail end unit –after ESP
- Unique ammonia injection mixing
- Ceramic media for heat transfer
  - Provides uniform gas distribution to catalyst
- Catalyst bed above heat transfer bed
- Multi-chamber design
- Beds cycled rapidly to ensure proper gas temperature into catalyst

Capable of >75% NOx Reduction

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RSCR- Commercial Units

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16 MW Bridgewater Power

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16 MW Unit- Bridgewater Power
New Hampshire

- 16 MW WFB (2 can unit)
- Whole tree chips
- Targeted CT REC program (0.075 lb/MBtu)
- Inlet 0.28 lb/MBtu
- Able to achieve **< 0.05 lb/MBtu**
- Started up October 2007
- Made quarterly average

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RSCR-CO

- Ongoing BPEI development program to enhance the technology
- Testing indicates 50 to >75% reduction of CO
- Precious metal catalyst on metal monolith
- Enables simultaneous NO_X & CO reduction in single system
- Low (<1" WG) pressure drop across each bed
- Proven catalysts used

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Emissions Control Technologies

Summary

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Emissions Summary- Coal & Biomass

lb/MBtu	**Coal**		**Biomass**	
	Uncontrolled	*Controlled*	*Uncontrolled*	*Controlled*
NOx	0.32 to >1.5	0.035 to 0.15 (SCR)	0.15 to 0.48	0.05 to 0.075 (RSCR)
SO2	0.8 to >6.0	0.03 to 0.06 (FGD)	<0.08	<0.08
CO	0.04 to 0.15	0.04 to 0.15	0.15 to 0.45	0.075 to 0.10 (catalyst)
PM	3 to 15	0.012 to 0.02 (ESP/BH)	0.2 to >1.0	0.010 to 0.015 (ESP)

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Biomass Co-firing Options

1. One approach - biomass fuel mixed w/coal and prepared thru the pulverizer
   - Limits on amount of biomass fuel
   - Pulverizer capacity issue
2. Fire biomass through burners with dedicated biomass grinder
3. Combust on a separate/dedicated grate

Typically 10% to 20% by heat input limit

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Issues with Biomass Co-Firing with Pulverized Coal

- Areas to carefully evaluate
  - Fuel handling and mixing
  - Burners
  - Boiler fouling and slagging
  - Environmental equipment (ESP & SCR)

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Summary

- Biomass is a sustainable renewable resource
- Fuel is plentiful in certain parts of the country
- Growth rate for new biomass power projects is high
- Trend is to use well proven, efficient, and reliable combustion technologies
- Trend is to lower emissions, which can be controlled to low levels

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Thank You

Questions?

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