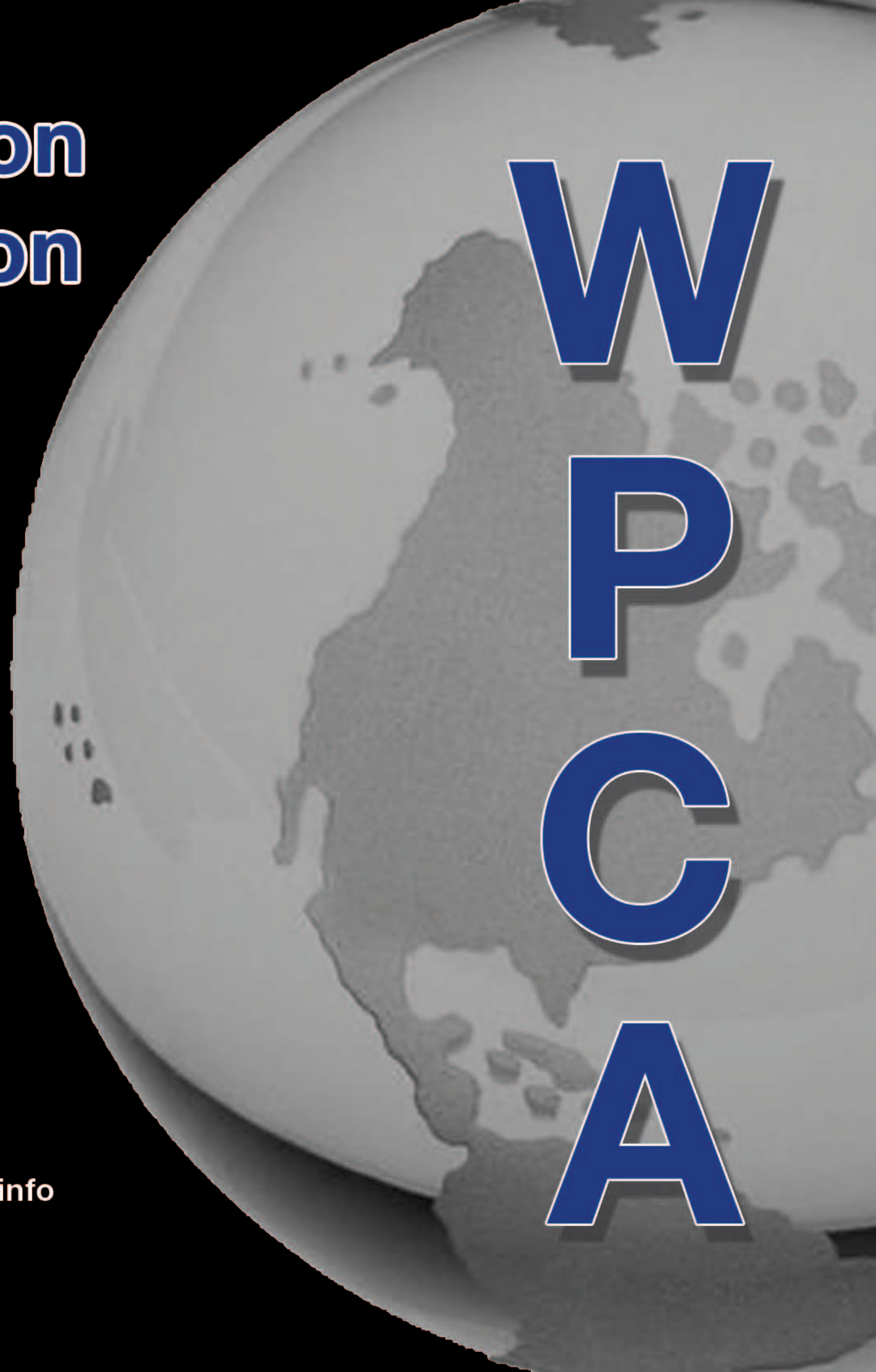
Worldwide Pollution Control Association

Duke Energy Seminar

September 3 – 5, 2008

Concord, NC



WPCA

Vist our website at www.wpca.info

Babcock Power Inc.
Overview

One Source *Many Solutions* *One Purpose*

For:
WPCA/Duke Seminar

Craig Penterson & Tony Licata
Babcock Power Inc.

September 4, 2008

Agenda

- Introduction
- Biomass Fuels, Issues and Options
- Biomass Co-firing
- Biomass Retrofit/ Conversion of Existing Units
- Applications
- Biomass Stoker Technology
- Regenerative Selective Catalytic Reduction (RSCR) Technology
- Summary

General Fuels Experience

Coal	Lignite, Sub bituminous, Bituminous, Anthracite
Oil	#2 - #6 Crude
Gas	Natural Gas, Process Gases, Waste Gases
Refuse	Municipal Solid Waste, Refuse Derived Fuel
Petroleum Coke	Fluid, Delayed
Biomass	Wood waste, Wood Chips, Wood Sawdust, Wood, Bark, Bagasse, Sunflower Seed Hulls, Coffee Grounds, Furfural , Paper Waste

Fuel Considerations for Boiler Design

Fuel parameter	What does it affect?	Impacted equipment / design
• **Ultimate analysis** • **Heating value**	• Air & flue gas flow rates, draft loss • Boiler efficiency, heat rate	• Flue gas flow area – tube spacing • Duct and flue gas equipment sizing • Fan sizing / margins
• **Moisture content**	• Air & flue gas flow rates, draft loss • Boiler efficiency, heat rate • Fuel drying & mill capacity	• Grate sizing • Mill Design • Hot air temperature required
• **Sulfur content**	• SO_2 / SO_3 production • Acid dew point temperature	• Potential for AH / duct corrosion • Desulfurization equipment sizing
• **Ash content**	• Ash production • Erosion potential	• Ash removal equipment • Flue gas flow area / velocity limits
• **Ash initial deformation temp.** • **T_{250} temperature**	• Furnace slagging potential • Furnace efficiency / heat absorption	• Sootblowers • Furnace size / platen surface area
• **Ash mineral analysis: Na_2O, CaO, KO**	• Convection pass fouling potential	• Tube clear space requirements • Sootblower application

Common Biomass Fuels

Wood Chips, Wood Sawdust, Wood Bark, Sunflower Seed Hulls, Coffee Grounds, Furfural , Paper Waste, Bagasse

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*

Biomass Issues

Emissions - the Primary Concern

Pollutant	Emissions
• PM	Low (ESP)
• SO_2	Low
• HCl	Low
• CO	Moderate
• VOC	Low
• NOx	Moderate/High

NOx and CO are main pollutants

Biomass Options

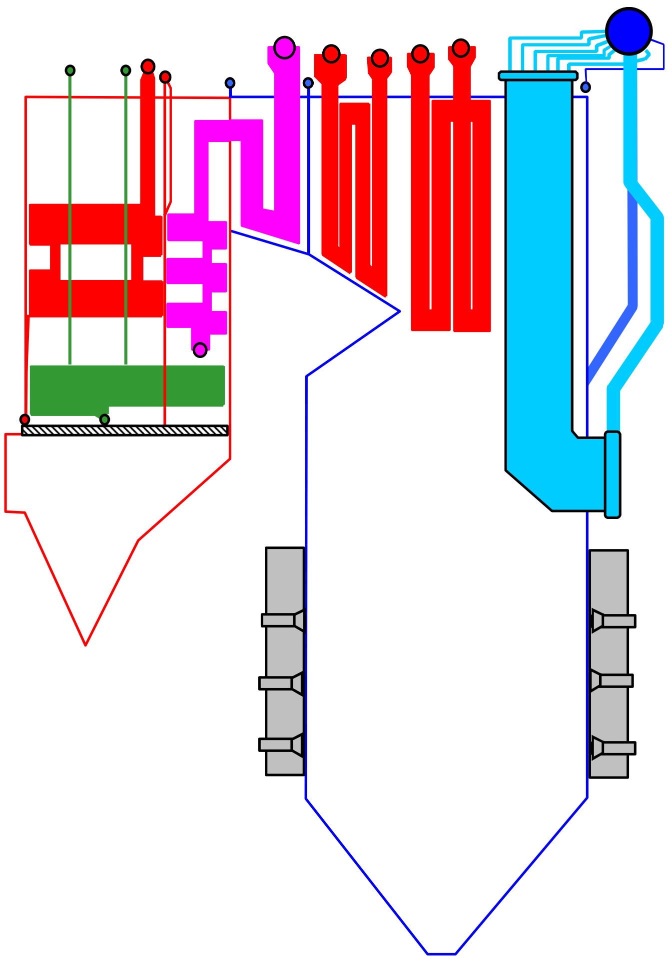
1. Co-firing in existing boilers
2. Retrofit/conversion of existing units
3. New boilers

Performance and Design Considerations

- Advanced Biomass Stoker Design
- Regenerative Selective Catalytic Reduction (RSCR)

Performance and Design Considerations

- Fuel Fired
- Firing Configuration
- Mill Design & Operation
- Burner Sizing
- Furnace Sizing
- Furnace Performance
- Convection Pass Design Criteria
- Spacing of Tube Assemblies



Biomass Co-firing

- Typically biomass fuel mixed w/coal and prepared thru the pulverizer
- Up to 10% biomass fuel
- Areas to evaluate
  - Fuel handling and mixing
  - Pulverizer capacity
  - Burners
  - Boiler fouling and slagging
  - Environmental equipment

Biomass Co-Firing with Pulverized Coal

Options:

1. Fire thru separate burners (sander-dust)
2. Mix w/raw coal pass thru pulverizer and burners
3. Combust on a separate/dedicated grate

   Typically:

   - Wood chips
   - Up to 10% by heat input

Biomass Co-Firing with Pulverized Coal, (con't)

1. Evaluate fouling and slagging of the mixed fuel

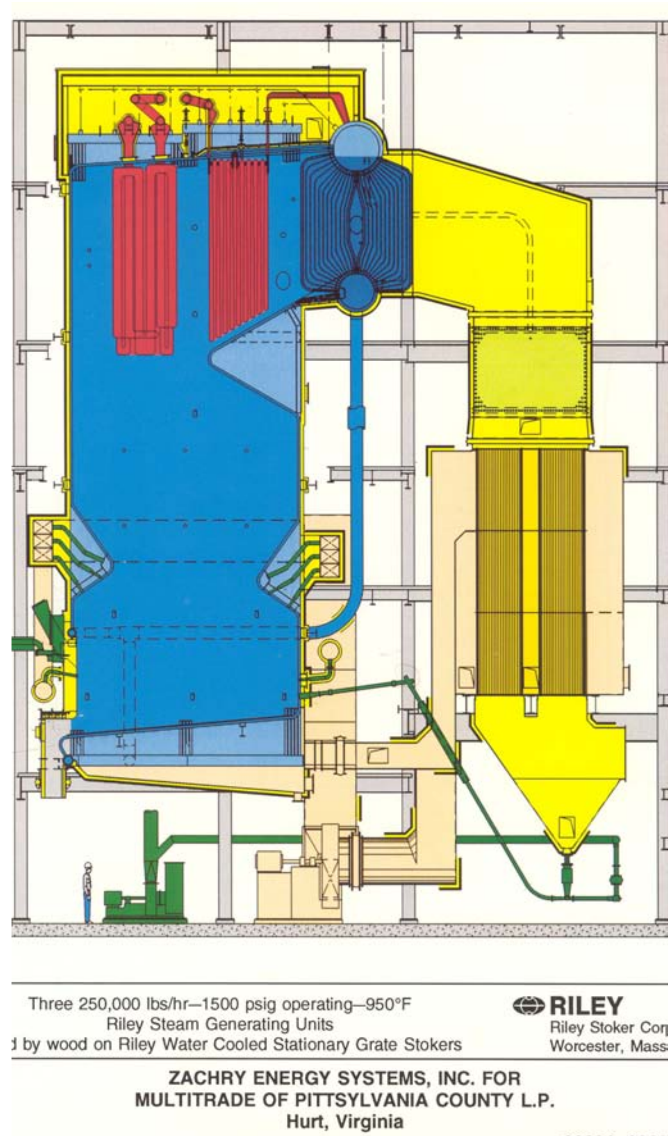
Biomass Retrofit/Conversion of Existing Units

- Establish fuels
- Evaluate the boiler capacity firing biomass
- Review required modifications
- Perform a feasibility study
  - Phase 1 Feasibility Study
  - Phase 2 Initial engineering phase
  - Phase 3 Detail
  - Phase 4 Modification and start-up phase

New Boiler

Biomass Boiler Industrial, IPP (wood, wood waste, bagasse, coffee grounds, etc.)

• Stoker Combustion	Steam Flow	Temp	Pressure
	100,000-500,000 Lbs/hr	650-955℉	650-1600 psi



Biomass Stoker Technology

Advanced Biomass Stoker Design

- Consist of both combustion and boiler components.
- Complete System, not stand–alone components.

Zone 4

Minimize gas velocity stratification through tube banks

- Reduce tube erosion
- Reduce temperature unbalances

Zone 3

Uniform flue gas distribution

- Minimize gas velocity stratification
- Complete CO burnout
- Minimize char particle entrainment to reduce carryover

Zone 2

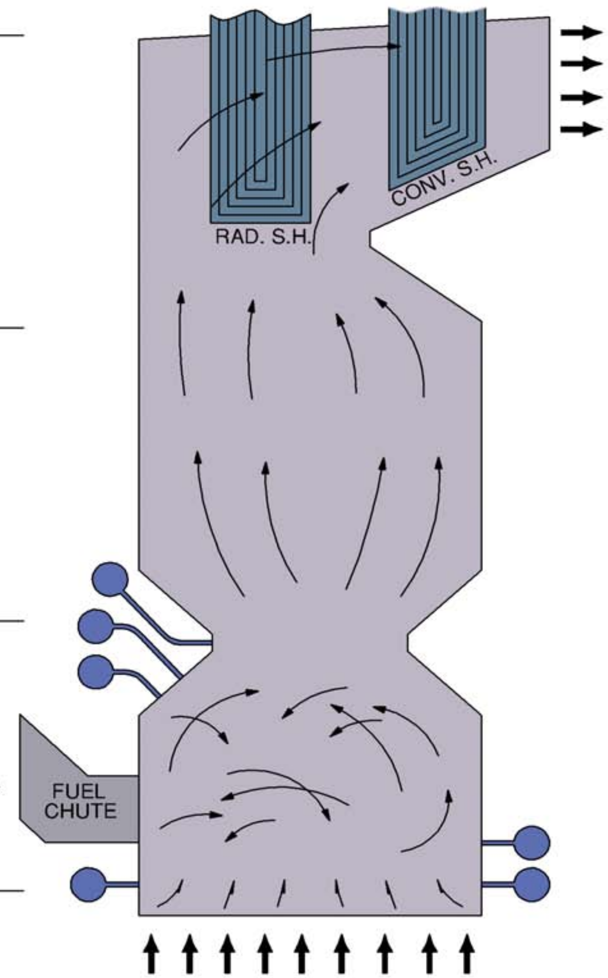
Maximum turbulence, mixing, and penetration of OFA for complete suspension burning

- Reduce stratification and the water walls
- Increase the retention time in the combustion zone

Zone 1

Even fuel distribution on the grate OFA system is not to disrupt fuel distribution on the grate

- Fuel drying
- Fuel ignition



Reliable “Proven” Stoker Design (Advanced Stoker Combustion Systems)

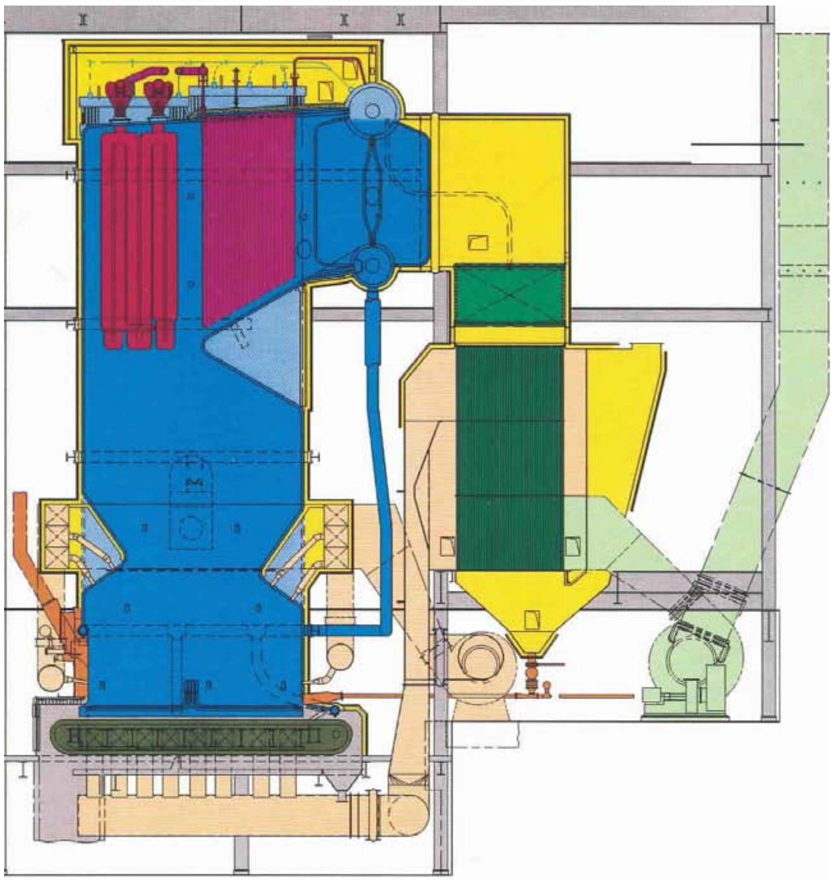
- Reliable Mechanically (low velocities, straight ash reinjection, etc.)
- Reliable Performance (low heat release rates, high furnace retention time)

Goals of Advanced Stoker Combustion Systems

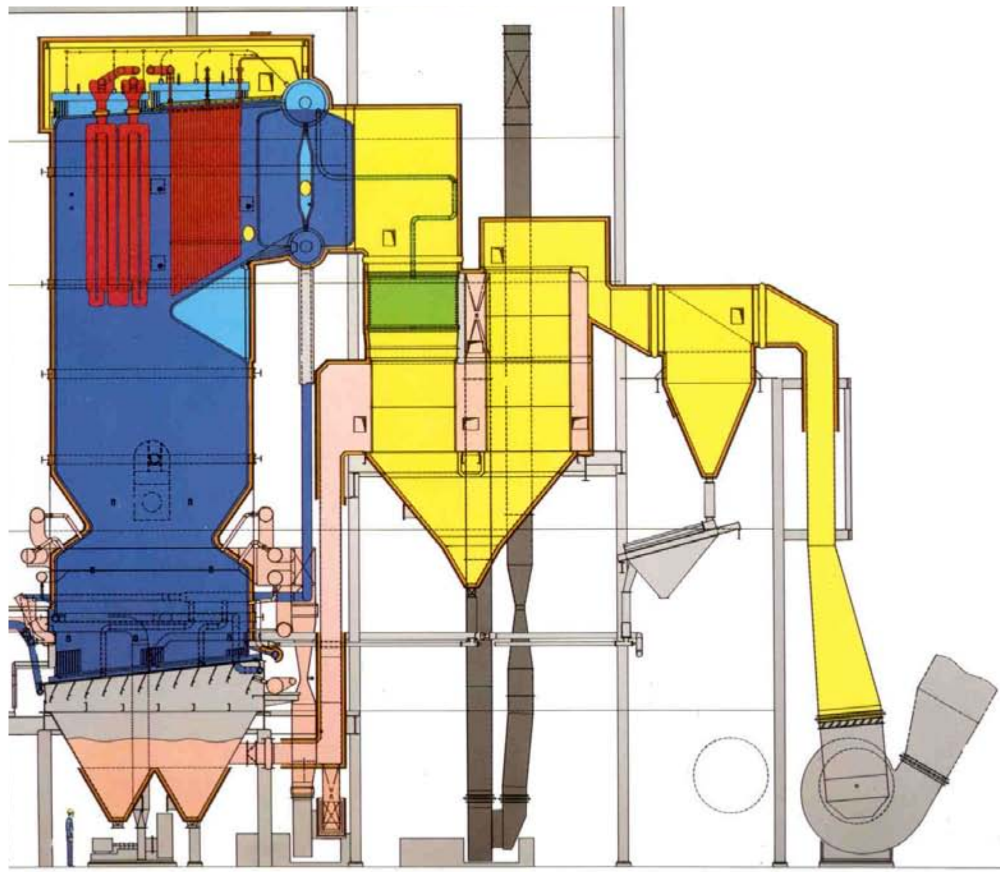
1. Efficient Combustion
   - Low unburned carbon
   - Low carbon monoxide emissions
2. Stable Combustion
   - Stable heat input resulting in stable boiler steaming conditions
3. Low Emission
   - Low CO, NOx, and UBC (unburned carbon)
4. High Boiler Efficiency
   - Low stack temperature
   - Low excess air
   - High steam temperature
   - High boiler pressure

Example Applications

KES FITCHBURG, L.P.
Westminster, Massachusetts
One 170,000 lbs/hr—1280 psig operating—955°F
Riley Steam Generating Unit
Fired by wood chips on a Riley Harrington Stoker
RILEY STOKER CORPORATION WORCESTER, MASSACHUSETTS



CNF CONSTRUCTORS, INC. FOR
RYEGATE POWER STATION
East Ryegate, Vermont
190,000 lbs/hr—1475 psig design—1280 psig operating—955°F
Riley Steam Generating Unit
Fired by whole tree chips
Stone & Webster Engineering Corporation, Consulting Engineers
RILEY STOKER CORPORATION WORCESTER, MASSACHUSETTS



RSCR

System to Reduce NOx Emissions from Biomass Boilers

Tony Licata

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

Regenerative Selective Catalytic Reduction (RSCR)

- New technology
- Development goal was high thermal efficiency/low total cost for WFB, WTE, and industrial boilers
- First RSCR system operating on US biomass boiler

Initial RSCR Drivers
Low NO_X Emissions

- **New England RPS Programs require low NO_X emissions**
  - 0.075 lb/MBtu (CT) (52 ppm)
  - 0.065 lb/MBtu (MA, NH) (45 ppm)
- **Applications elsewhere for NO_X offsets**
- **BACT**

Typical NO_X removal efficiency required ~ 75%

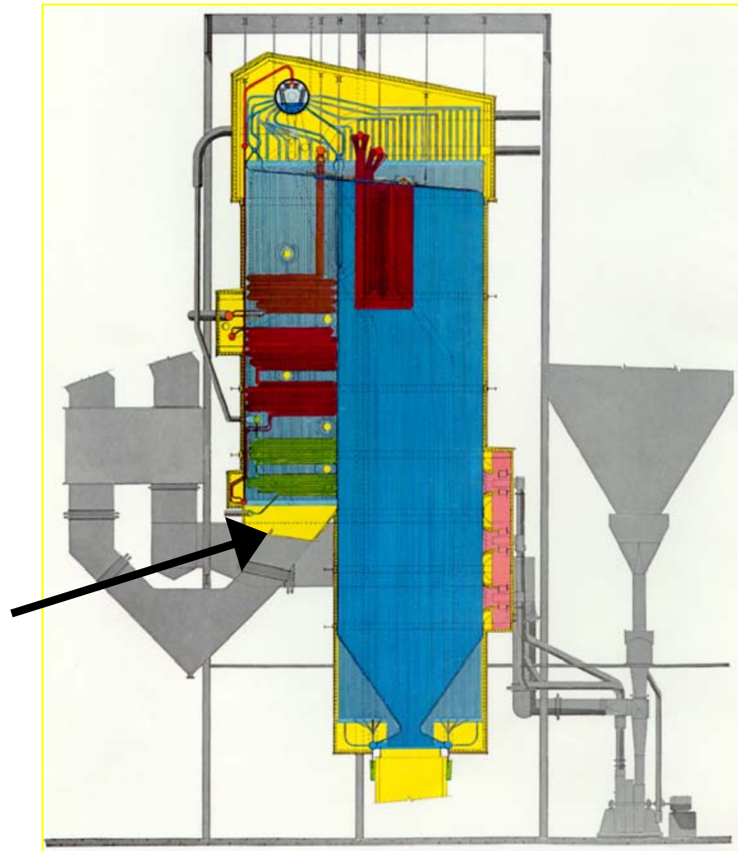
Biomass Options to Achieve Low NO_X/CO

- "Conventional" technologies can't get reduction
  - SNCR
  - OFA/FGR
- "Advanced" technologies can't get reduction
  - Ceramic injection tubes/NH_3 injection
  - High pressure rotating OFA/NH_3 injection

Conclusion: SCR required to achieve <0.075 lb/MBtu

“Conventional” SCR?
Where does it Fit?

- **Economizer outlet**
- **600° - 800°F**
- **Full flyash loading**



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 – very short catalyst life

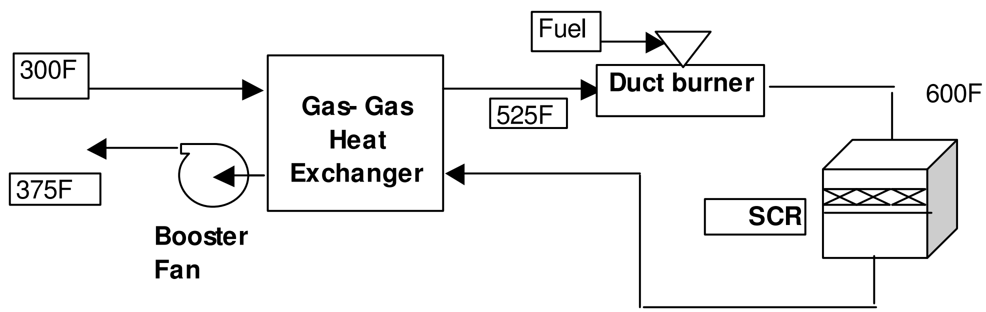
Difficult NO_X Control Applications

- Biomass boilers
- WTE furnaces
- Boilers with physical constraints (coal,oil)
- Process applications

Require the use of a "tail-end" SCR system

Typical Tail-End SCR Systems

- Installed downstream of particulate removal, upstream of stack
  - Clean gas
  - Low temperature gas (~ 300°F)
- Large physical size, high initial, erection, and operating costs
- Typical tail-end unit consists of:
  - HX
  - Duct burners
  - SCR
  - HX
  - Fan

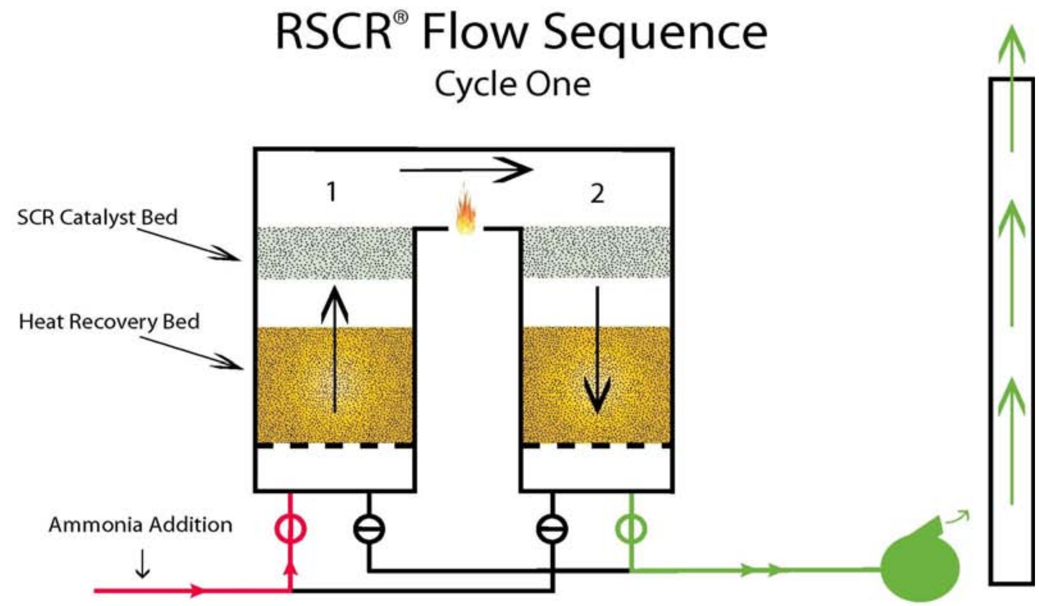


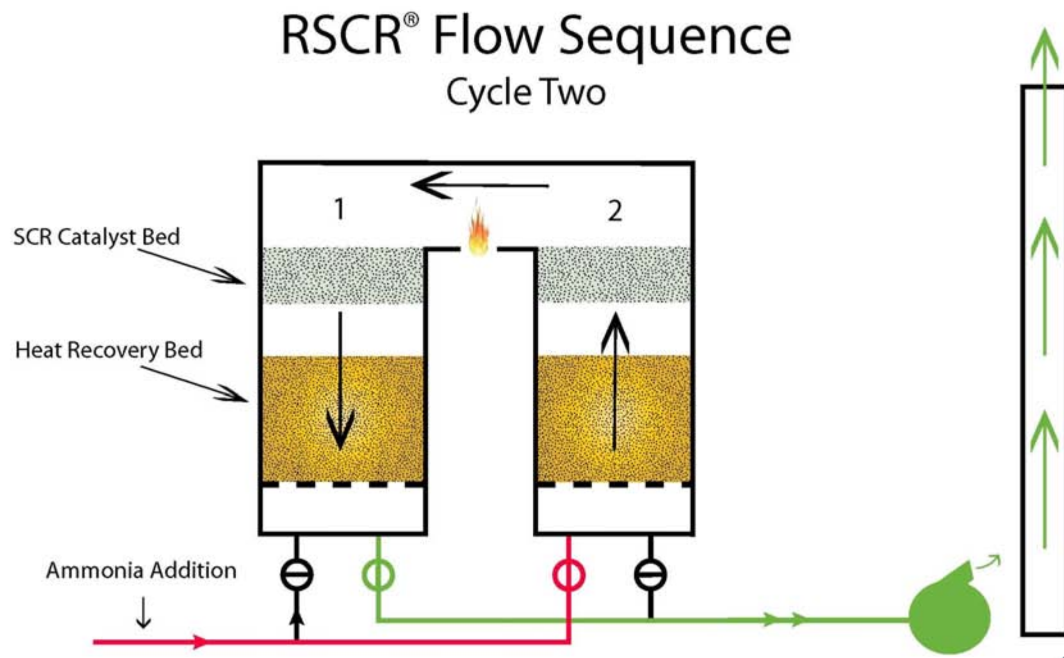
- NO_X reductions 60 - 90%; energy efficiency **~ 60 to 75%**

Regenerative SCR (RSCR)

- Targeted at tail-end applications
  - Gas relatively free of particulates, poisons (As, Pb, Na/K)
  - Low SO_3 content
  - Low temperature flue gas (approx 200° to 350°F)
- Achieves high heat recovery to minimize energy costs
- Modular, standard design to minimize installation cost
- Uses proven, guaranteed catalyst
- Proven high NO_X reductions
- **Thermal efficiency ~95% (1/10 the fuel of typical tail-end unit)**

RSCR Flow Sequence





RSCR Design

- 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

RSCR Thermal Module

- Based on conventional RTO/RCO system
- Over 4000 RTO units in operation since early 80's
  - Many industries; low gas temperature; particulate laden
- Issues on media, controls, valving, etc. have been solved

Key modification is addition of mixers, reactant, and catalyst dynamics

RSCR Features

- High NO_X removal efficiency
- Low energy consumption (>95% recovery)
- Self-contained tail-end unit
  - Includes fans, controls, burners
  - Simplifies installation
  - Tie-in with 2 day outage
  - Utilizes existing NO_X CEM or analyzer
- Bypass capabilities
- Off-line cleaning capabilities

RSCR Features (cont'd)

Modular Construction

RSCR Features (cont'd)

Installing Catalyst Modules

Headspace Burners

RSCR- Commercial Units

15 MW Wood Fired Unit

15 MW Unit- New Hampshire

- 15 MW WFB (1 x 3 can unit)
- Whole tree chips
- Targeted CT REC program (0.075 lb/MBtu)
- Inlet 0.25 lb/MBtu
- Able to achieve < 0.04 lb/MBtu (<28 ppm)
- Started up 10/2/04
- Made quarterly average since start up

Boralex Stratton 50 MW WFB

50 MW Unit

- 50 MW WFB (~450,000 lb/hr steam)
- Whole tree chips/waste wood/C&D
- Targeted CT REC program (0.075 lb/MBtu)
- Inlet 0.25 lb/MBtu
- Able to achieve < 0.04 lb/MBtu (<28 ppm)
- Started up 12/27/04
- Catalyst deactivation evaluated – >5 years
- Met quarterly average since start up

16 MW Bridgewater Power

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 < 0.04 lb/MBtu (<28 ppm)
- Started up October 2007
- Made quarterly average

54 MW Unit- Burlington Electric Vermont

- 54 MW WFB (6 can unit)
- Whole tree chips/urban wood
- Targeting CT/MA REC program (0.065 lb/MBtu)
- Inlet 0.26 lb/MBtu
- Starting up October 2008
- Further technology improvements

RSCR Guarantees

- Emissions guarantee
  - ***Outlet NO_X***
  - ***NH_3 slip***
- Catalyst life
- Project schedule

RSCR - Summary

- Patented, proven technology for biomass
- High NO_X removal efficiency
- Low energy consumption
- Guaranteed performance

Enables biomass to be clean renewable energy

Thank You !