Application of Layered Control Technologies to Significantly Reduce NOx Emissions from Coal-Fired Boilers

James Tobin
David Moyeda
Wei Zhou
Roy Payne
GE Energy

2nd U.S.-China NOx Workshop
Dalian, China
August 2005

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Introduction

GE Environmental Services

Emissions Monitoring	CEMS, DAHS, SCR Control, Parts & Service, and Hg CEMS Monitor Over 1100 Systems Installed
Emissions Testing	Stack & RATA Testing, Hg Testing Executing more than 2000 Tests every Year
Evaluation Services	Turbine, Boiler, SCR, Precip & Baghouse Evaluations, Fuels Testing, & Consulting Evaluate over 500 systems every year
Emissions Control & Combustion Optimization EER Business Focus	LNB, OFA, SNCR, Additives, Boiler Optimization, Fuel & Air Balancing Hardware & Controls, Hg Control, Sorbent Injection for SO_2 Control 100+ Successful NOx Improvement Projects
Particulate Control	ESP & Baghouse parts, services, upgrades 4200 outages performed

An extensive team of air quality experts

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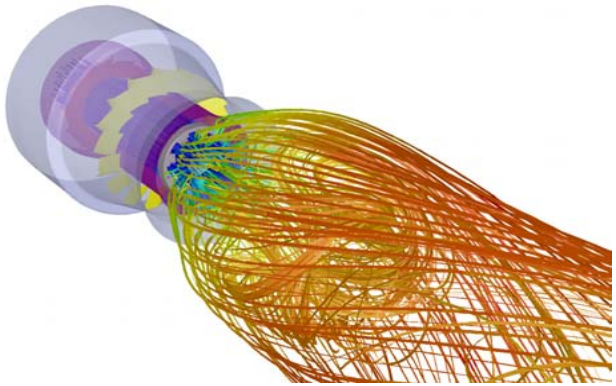
From concept to implementation

Combustion Test Facilities

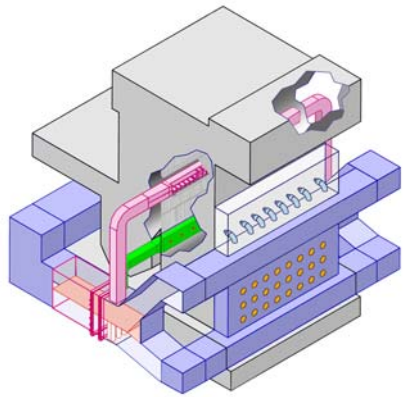
- Combustion test furnaces:
  - Boiler/Furnace Combustion Simulator
  - Package Boiler
  - SCR Catalyst Test Facility
- Fuels evaluation and testing
- Contract/internal R&D
- Consulting services

Design Engineering



- Process engineering tools:
  - Physical flow modeling
  - Computational fluid dynamics (CFD)
  - Heat Transfer models
  - Chemical kinetics codes
- Process engineering for new and retrofit applications
- Detailed design engineering

Installation & Commissioning



- Project management
- Procurement
- Instrumentation and controls
- Installation and construction support
- Start up and commissioning
- Testing and optimization services

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GE has retrofit a wide range of utility and industrial boilers with NOx control

Boiler types include wall, tangential, cyclone, and stoker firing configurations

Fuels include US and world coals, pet coke, fuel oil, Orimulsion, natural gas, biomass, etc.

Unit capacity ranging from package boiler size to 800 MW in generating capacity

Boiler & Furnace NOx Control

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Available NOx emissions control technologies vary in performance and cost

NOx Control Technologies	LNB	OFA	Reburning	SNCR	SCR
Components Involved					
Replace or Modify burners	X				
Staged Air Injection		X	X		
Staged Fuel Injection			X		
Nitrogen Agent Injection				X	X
Catalyst Reactor					X
Nominal NOx Reduction	30-50%	20-30%	50-60%	15-35%	80-90%

LNB = Low-NOX burners
OFA = Overfire Air
SNCR = Selective Non-Catalytic Reduction
SCR = Selective Catalytic Reduction

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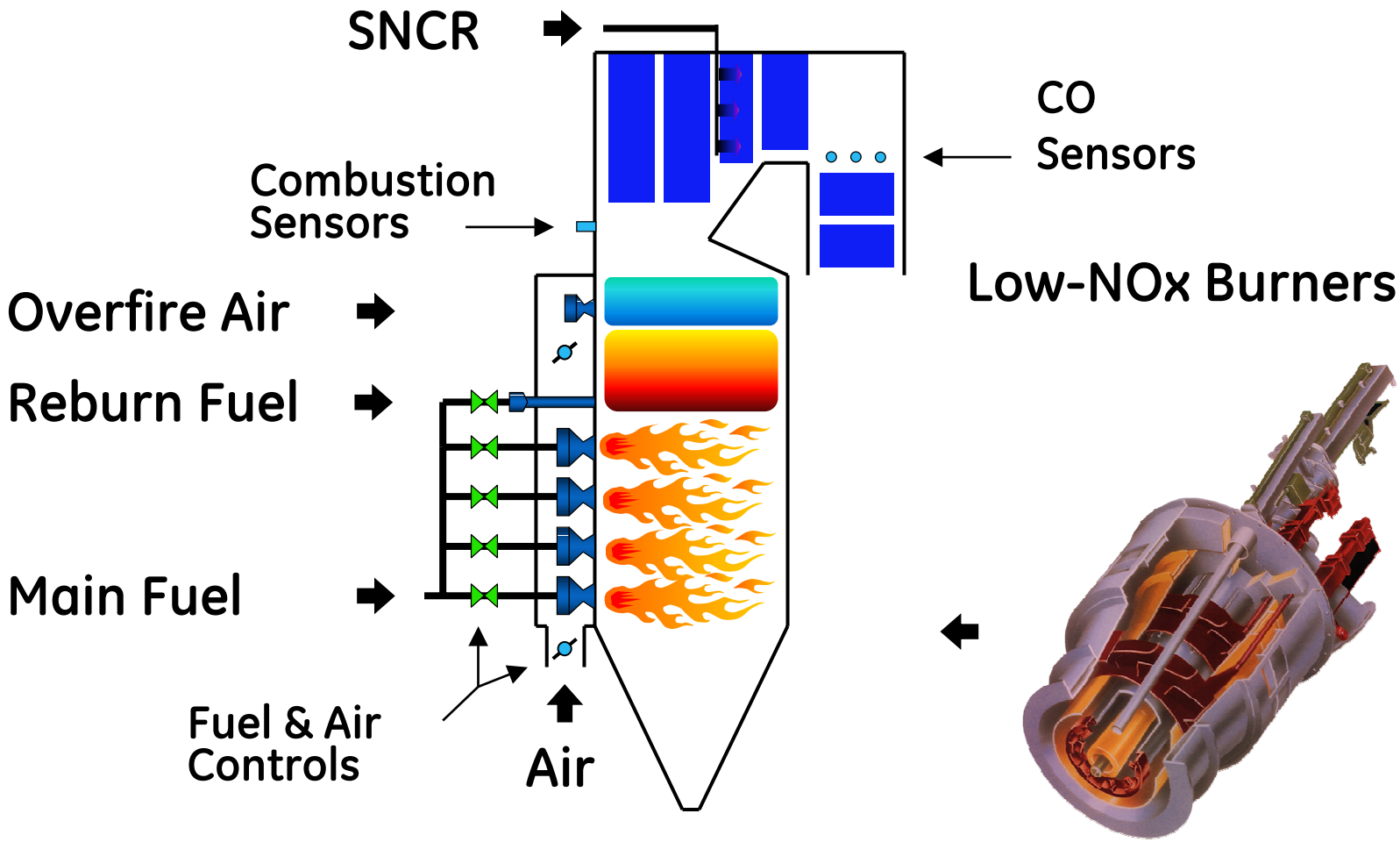
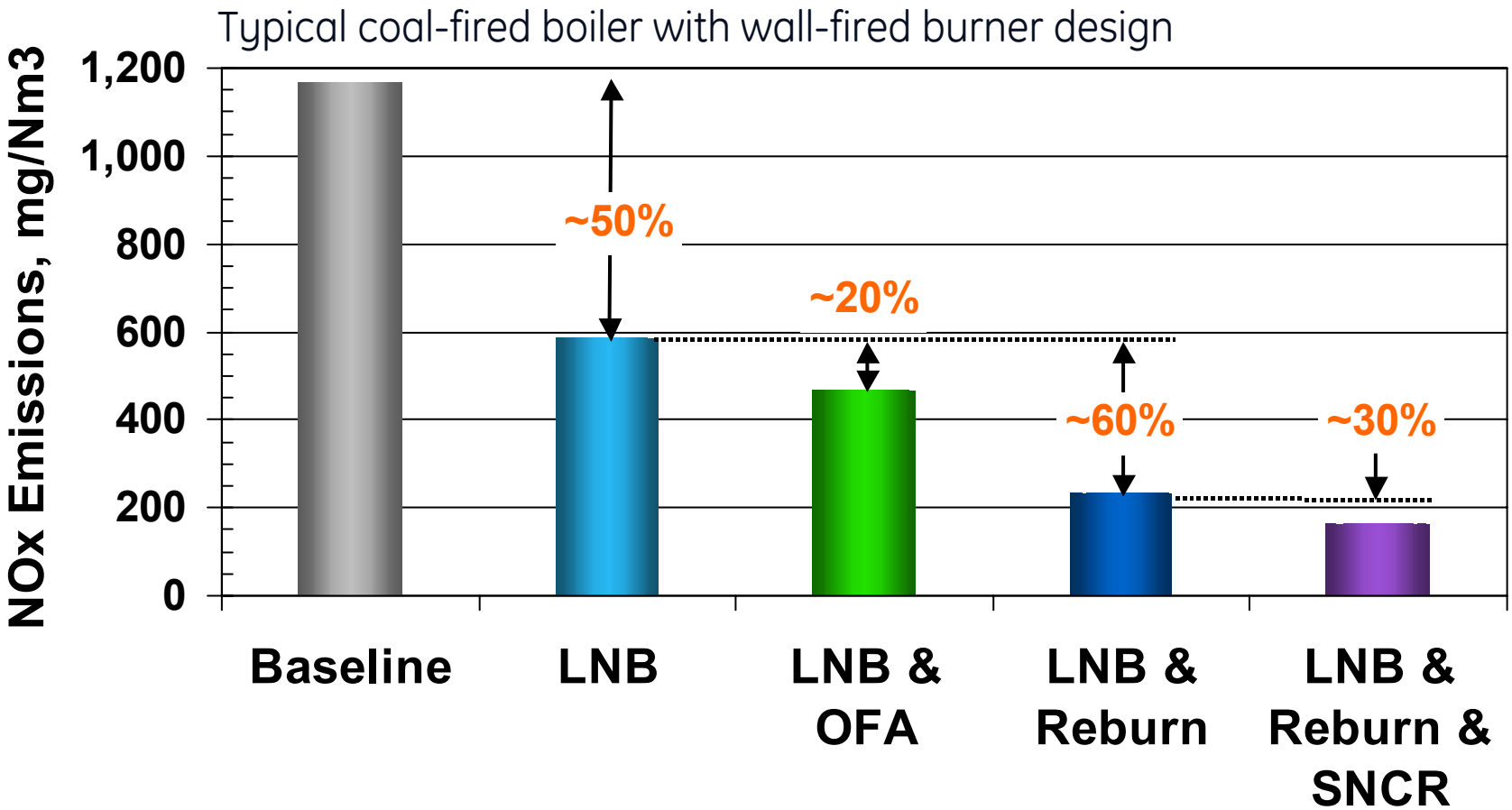
Technology layering provides unique approach to lowering NOx emissions



Layering of technologies can provide significant reduction of NOx



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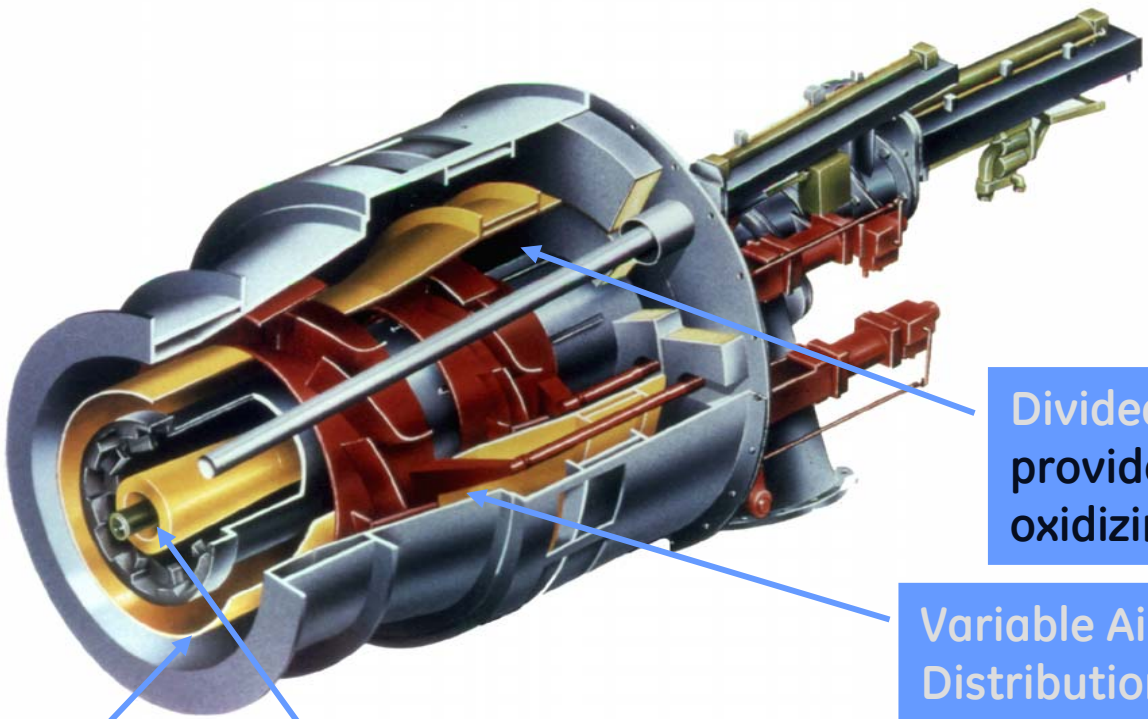
FlameMastEER™ Low-NOx Burner for coal-fired boilers



Divided Air Register
provides air staging, oxidizing envelope

Variable Air & Swirl Distribution
controls NOx and flame shape

Flame Stabilizer
anchors flame to coal pipe

Multi-Fuel Capable
coal designed with optional gas and oil co-firing

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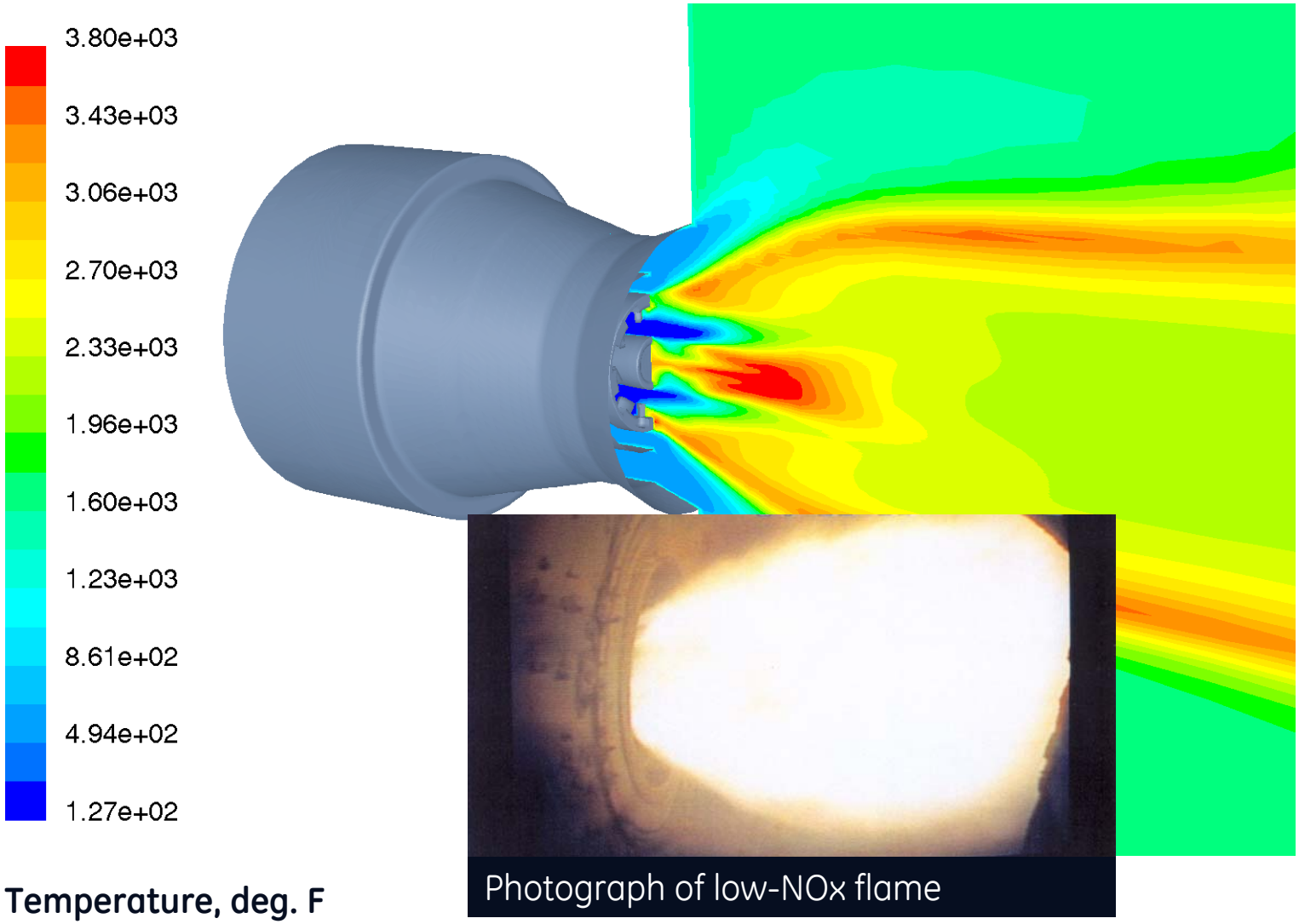
Flame stability key to LNB design



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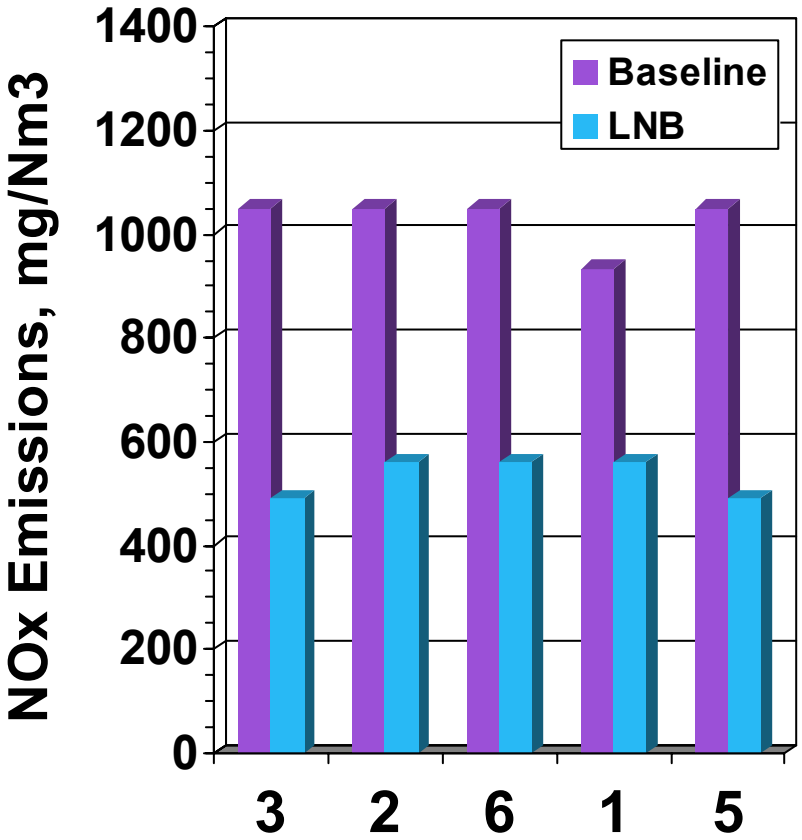
Wall-fired boilers retrofit with low-NOx burners



Comparison of uncontrolled and retrofit low-NOx burner emissions performance for five 120 MW boilers firing bituminous coal.

Typically > 50% NOx reduction for application of LNBs to most boilers.

Actual performance depends on boiler design and retrofit flexibility and coal characteristics.

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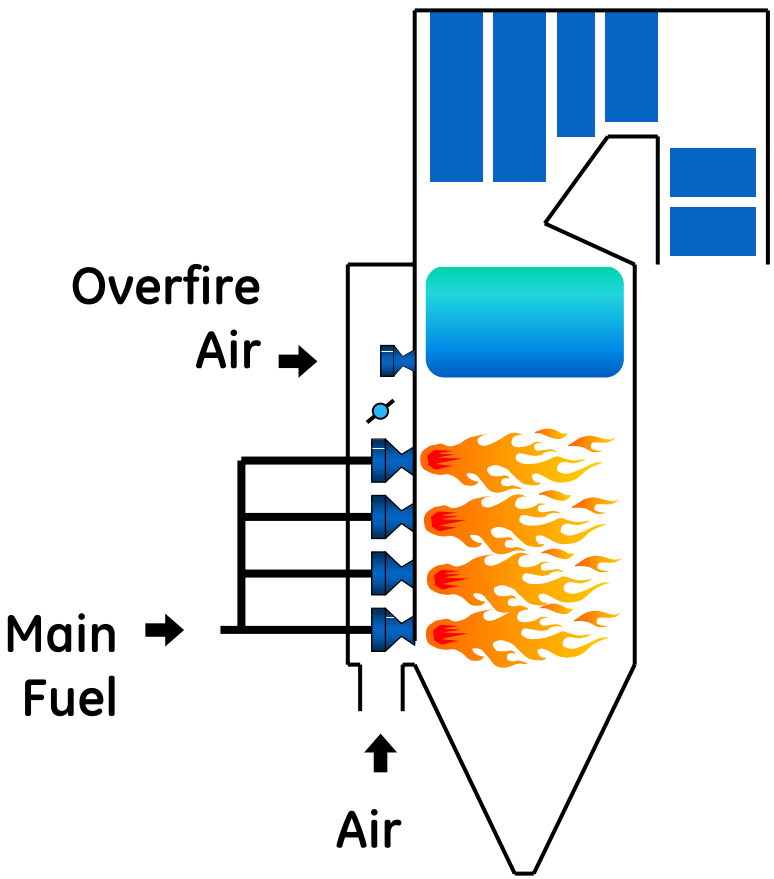
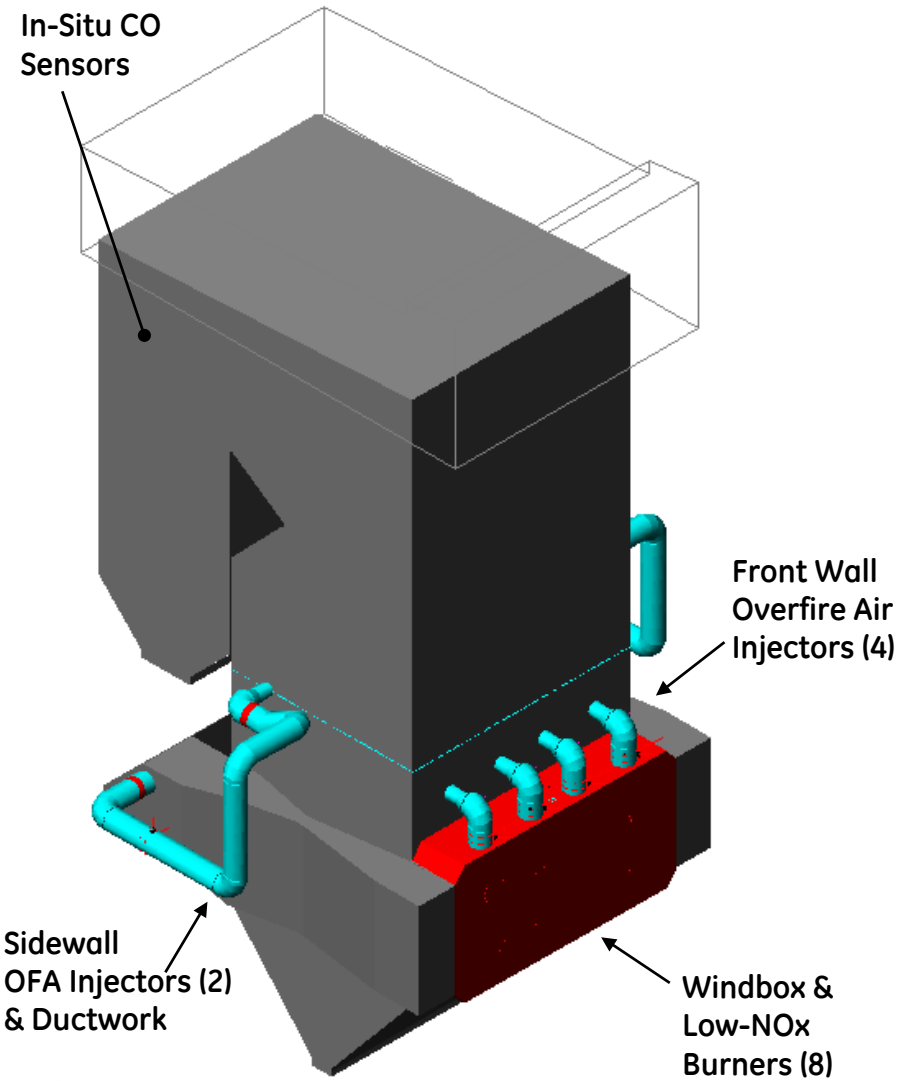
Overfire air consists of air staging to reduce NOx emissions

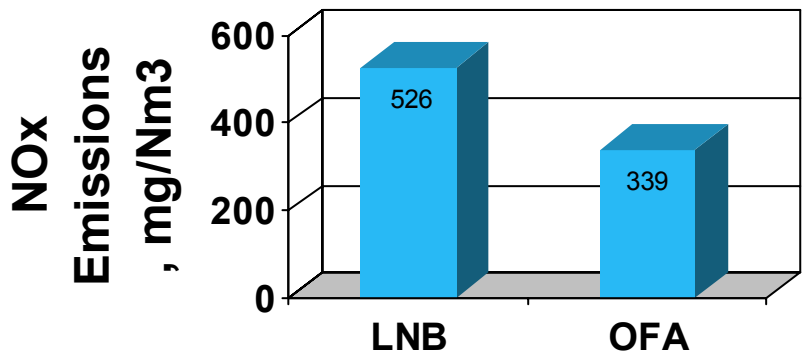


Overfire Air (OFA) moves a portion of the combustion air to a location higher in the furnace.

Like LNBs, staging of combustion reduces conversion of fuel-bound nitrogen into NOx.

Wall-fired boiler retrofit with overfire air





- Capacity, Fuel: 160 MW, Bituminous Coal
- Boiler Type: Front Wall Fired with low-NOx burners.
- OFA System: Six front wall and two sidewall injectors; customized injector design

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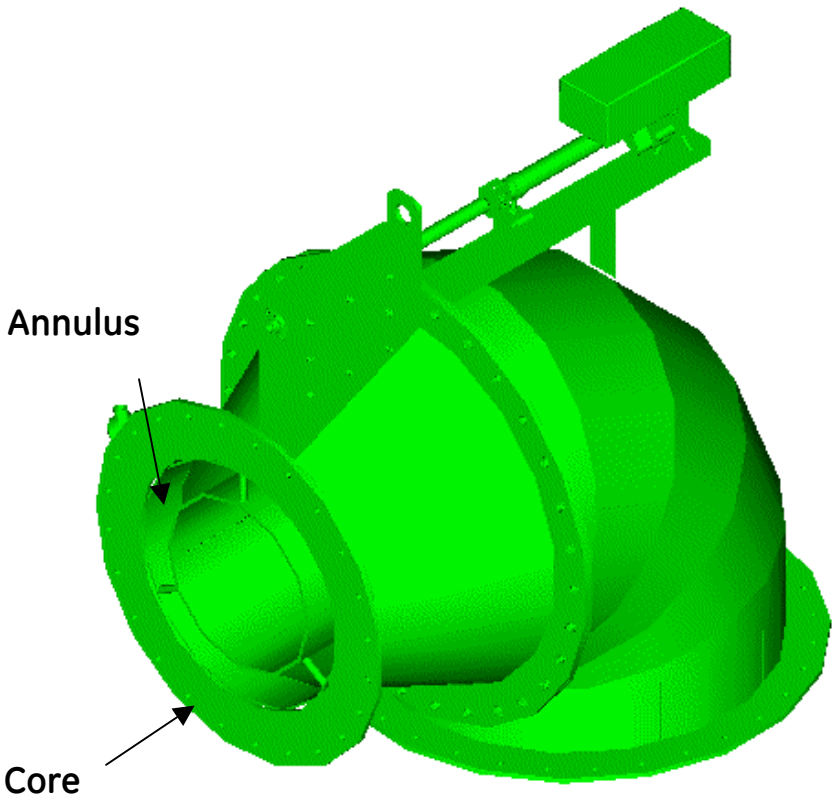
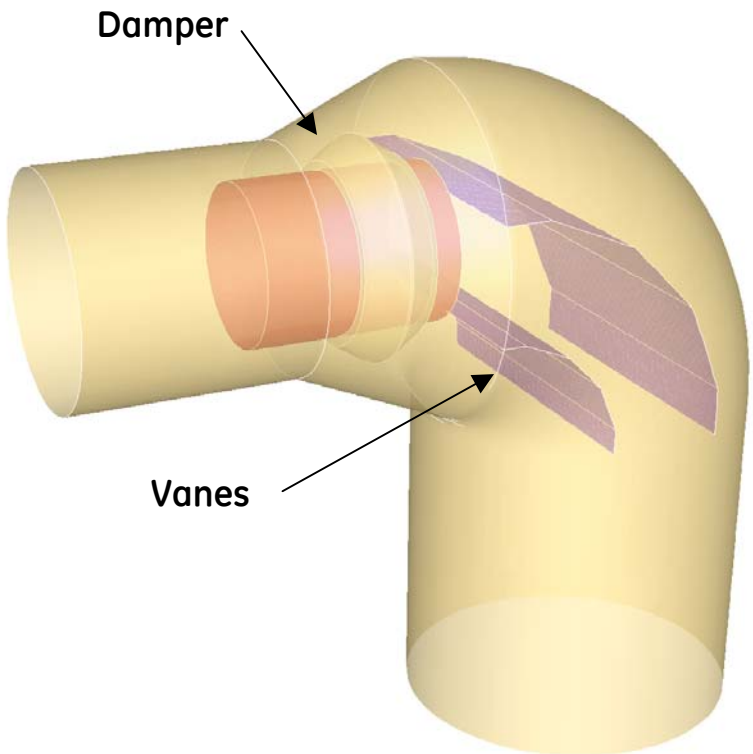
Customized overfire air injector

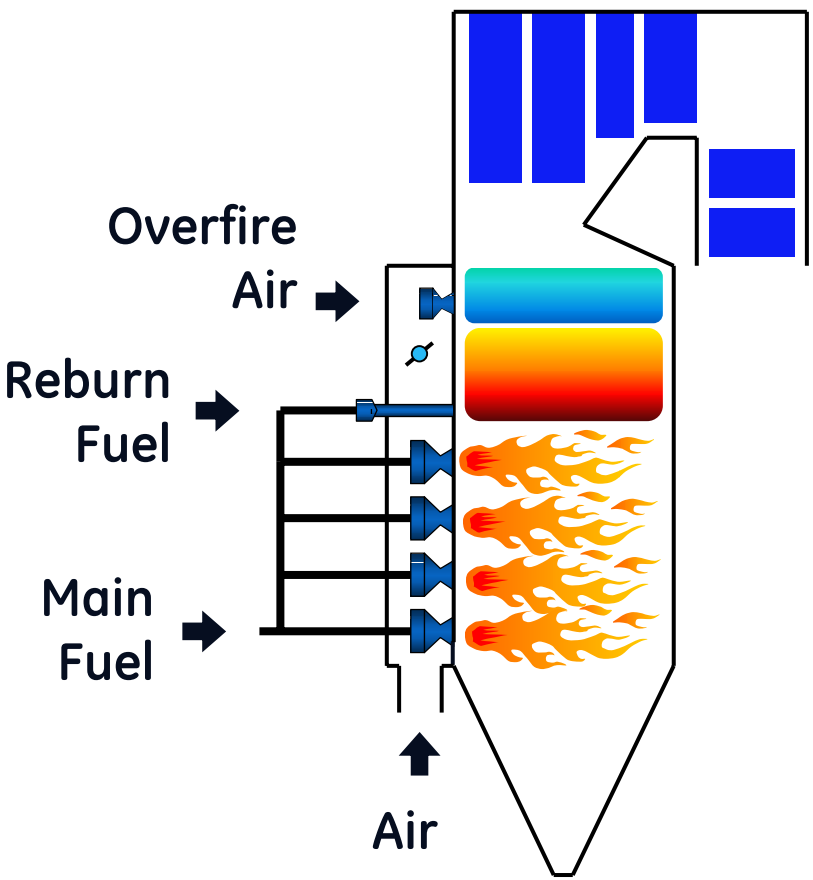
Detailed Design



Internals



Reburning process consists of both fuel and air staging



NOx generated in the main combustion zone reacts with fuel fragments injected into the reburn zone, reducing it to molecular nitrogen.

$$CH_4 \rightarrow CH$$
$$CH + NO \rightarrow HCN$$
$$HCN + OH \rightarrow NH_2$$
$$NH_2 + NO \rightarrow N_2$$

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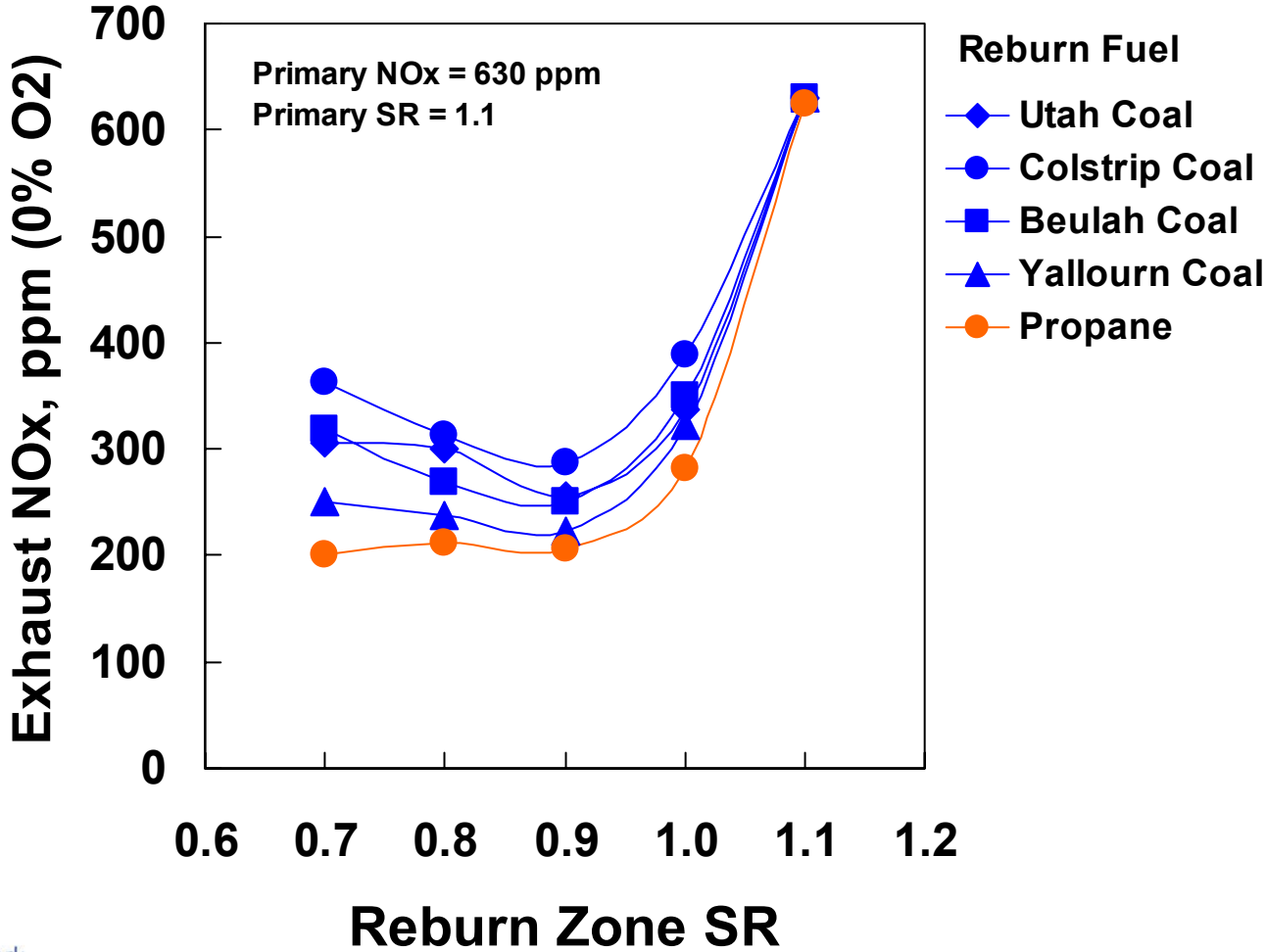
Reburn zone stoichiometric ratio is optimum around 0.9



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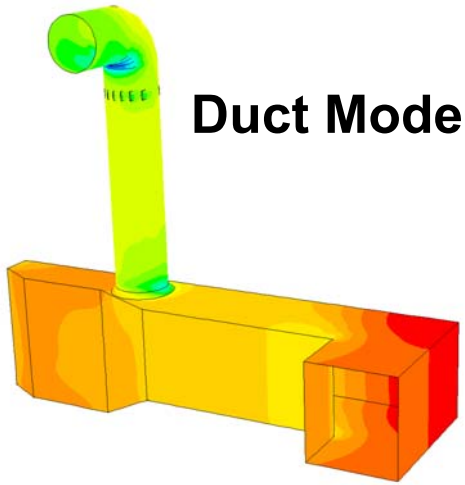
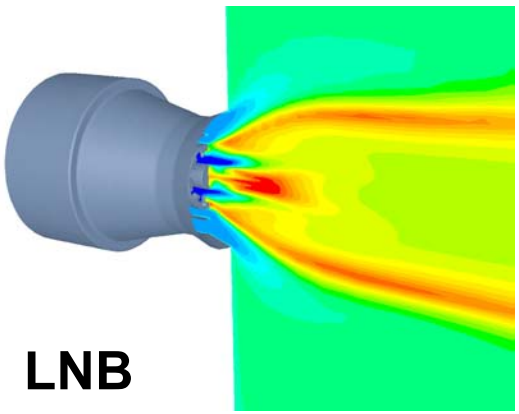
Advanced models are applied to ensure optimal performance

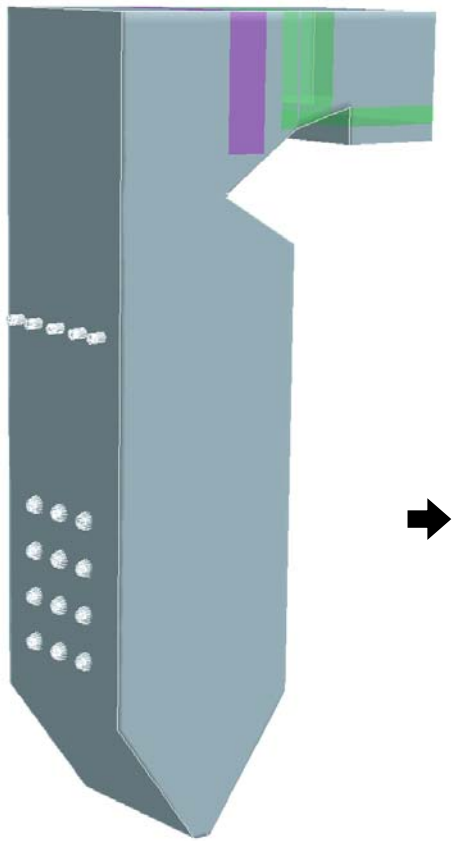


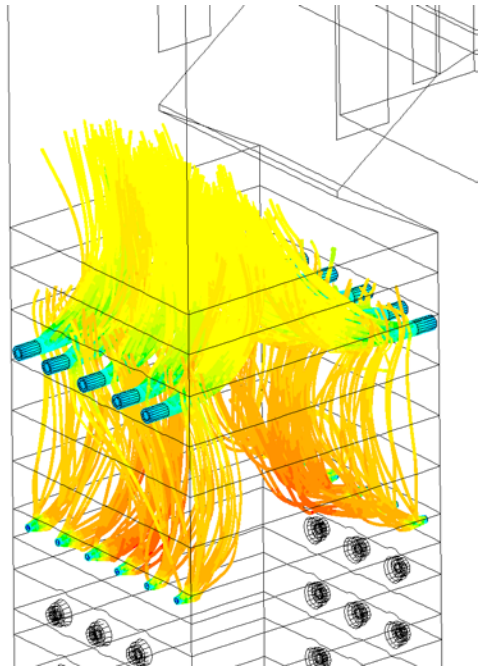
Duct Model



LNB

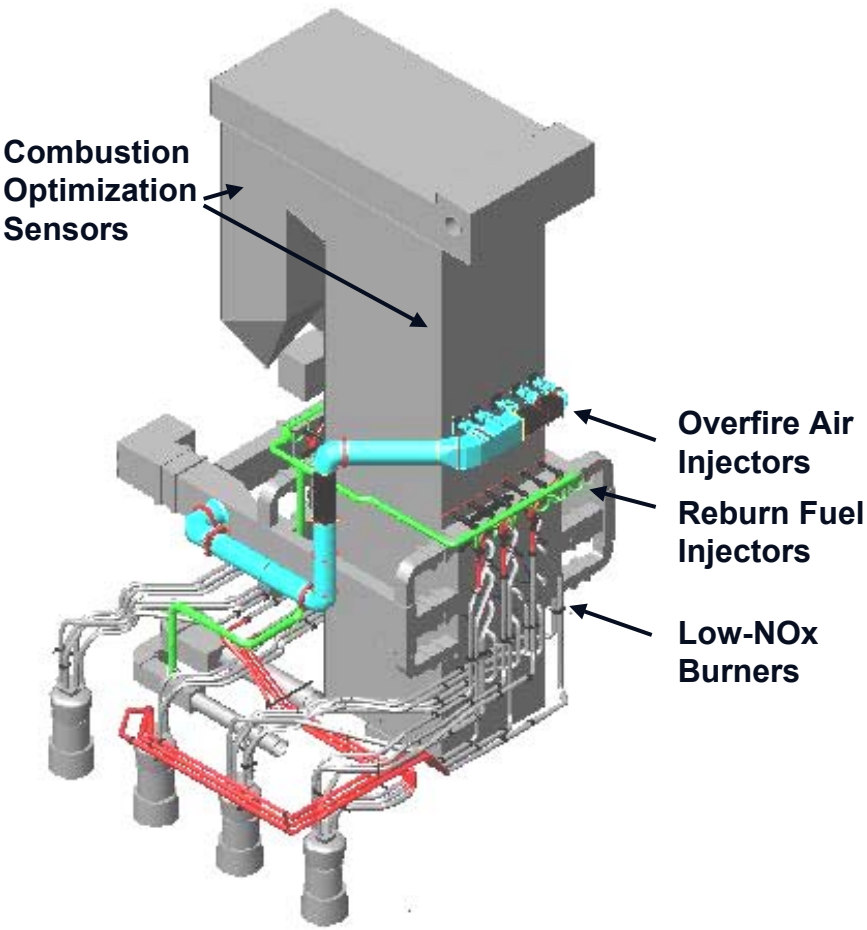
Boiler Model





Reburn & OFA Jet Pathlines

Opposed wall-fired boiler retrofit with low-NOx burners and coal reburn



- Plant: Green Station
- Capacity: 120 MW x 2
- Fuel: Bituminous coal
- Integrated NOx Control Solution:
  - Low-NOx Burners
  - Coal Reburn System
  - Combustion Sensors

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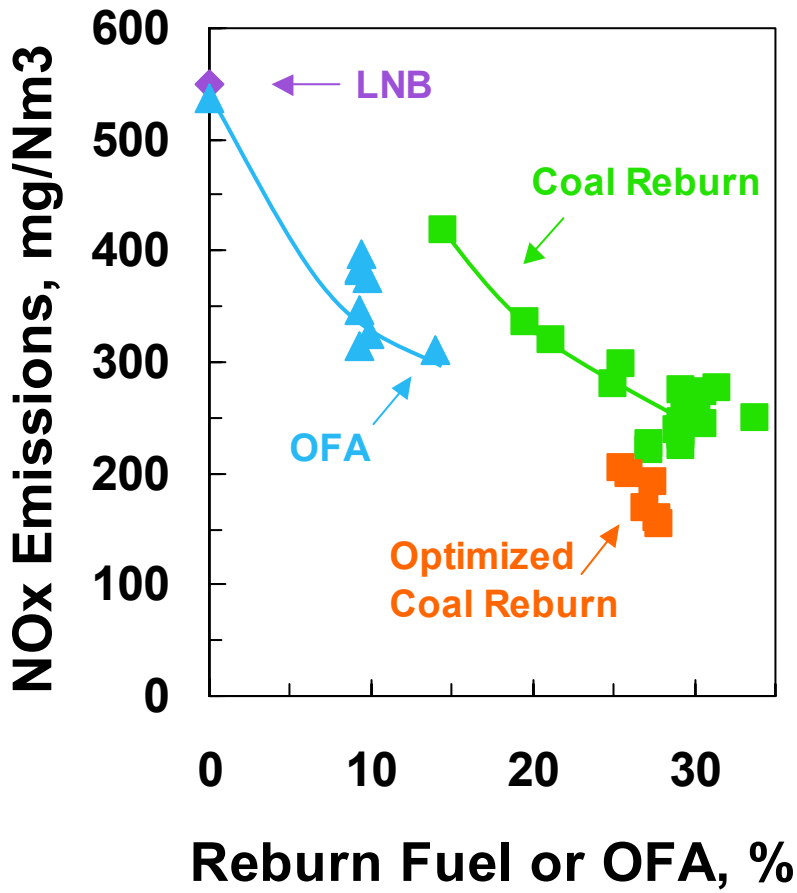
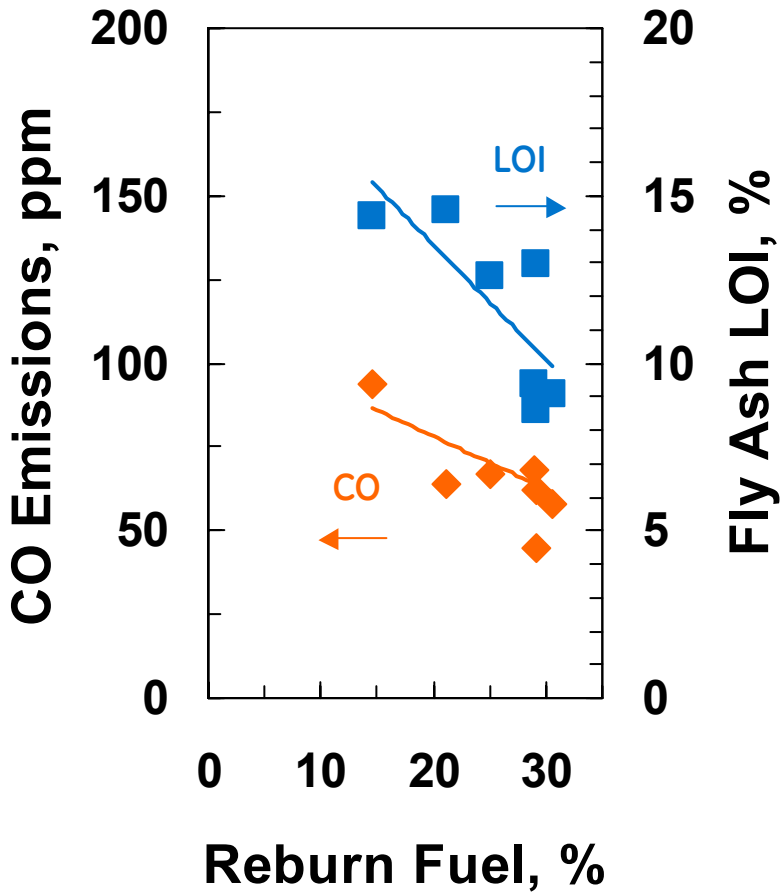
Coal Reburn provides effective NOx control with minimal boiler impacts





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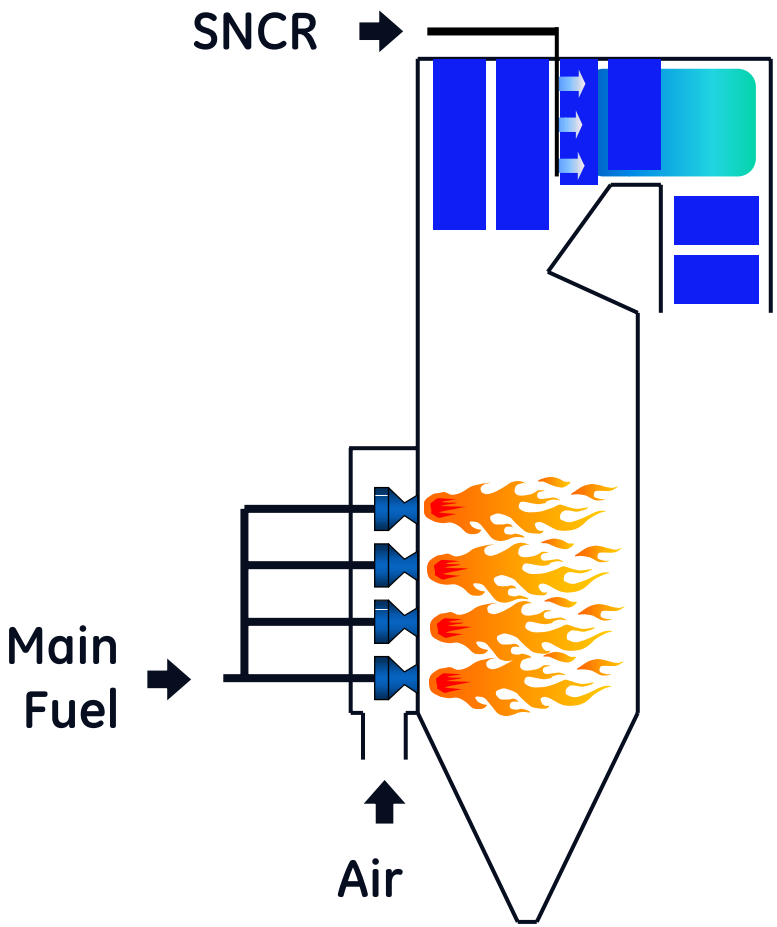
Selective non-catalytic reduction consists of nitrogen agent injection



At the proper temperature, the SNCR agent (for example, ammonia or urea) selectively reduces NO to molecular nitrogen.

$$NH_3 + OH \rightarrow NH_2 + H_2O$$
$$\downarrow$$
$$NH_2 + NO \rightarrow H + OH + N_2$$
$$\downarrow$$
$$H + OH \rightarrow H_2O$$

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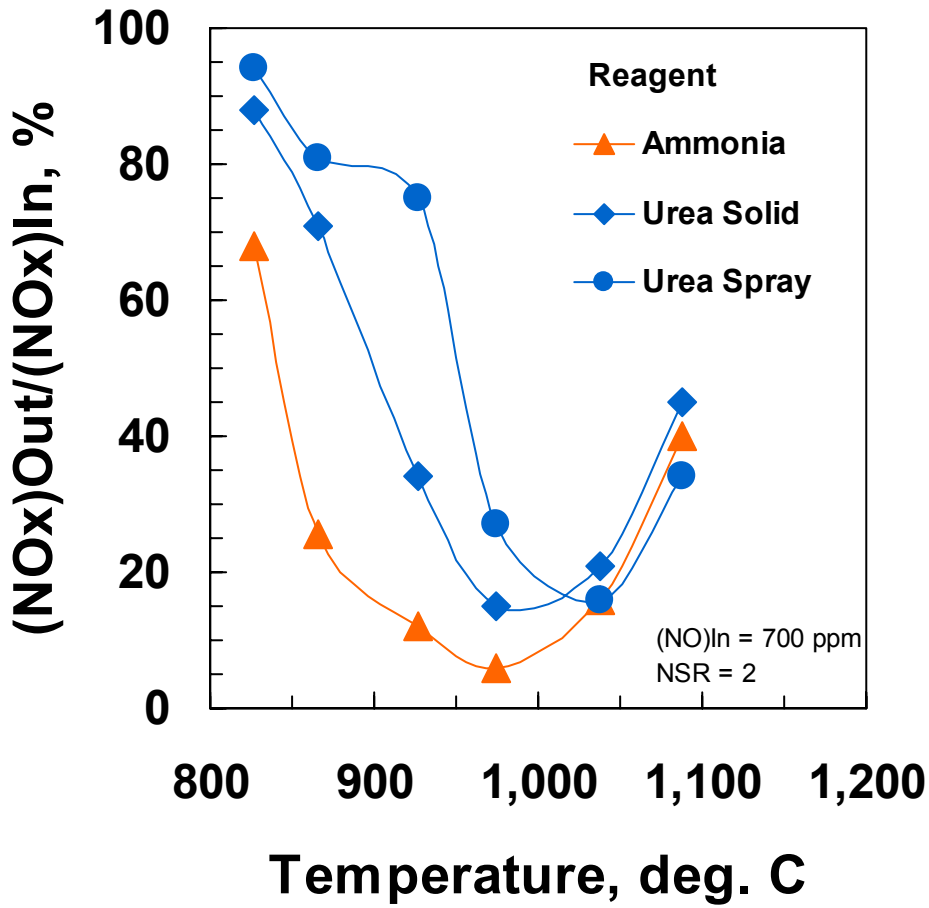
Optimum gas temperature for SNCR is around 1,000ºC



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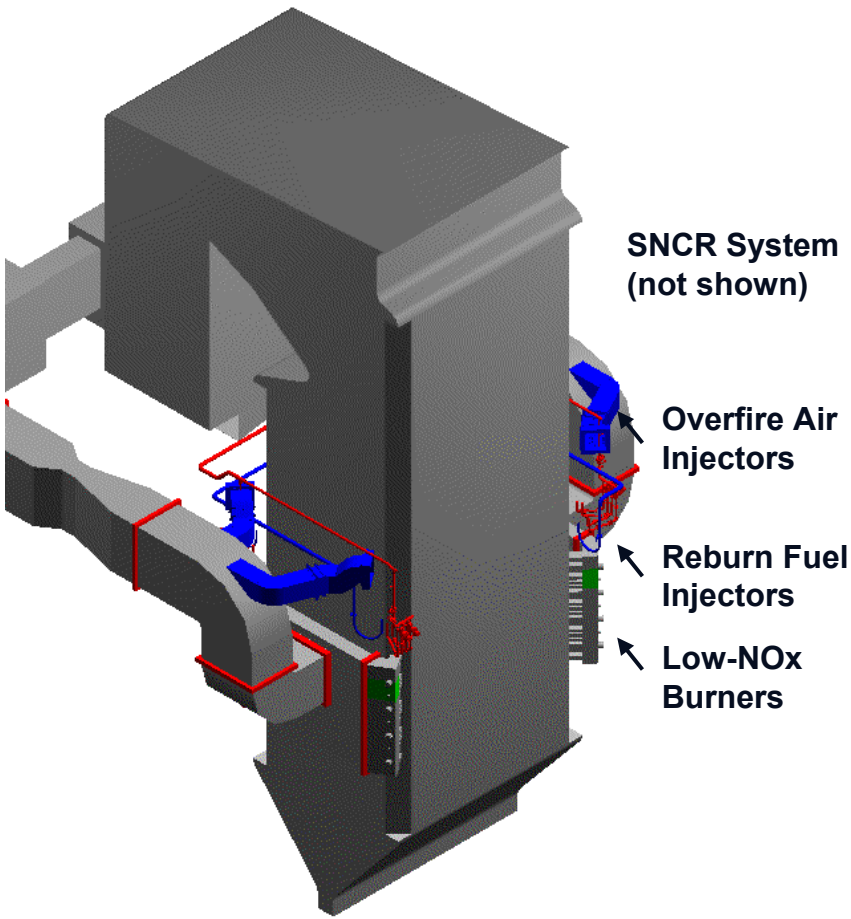
Tangentially fired boiler retrofit with low-NOx burners, reburn, & SNCR



- Plant: Somerset Station
- Capacity: 120 MW
- Fuel: Bituminous coal
- Integrated NOx Control Solution:
  - Low-NOx Burners
  - Gas Reburn System (including separated OFA system (SOFA))
  - Urea Injection System

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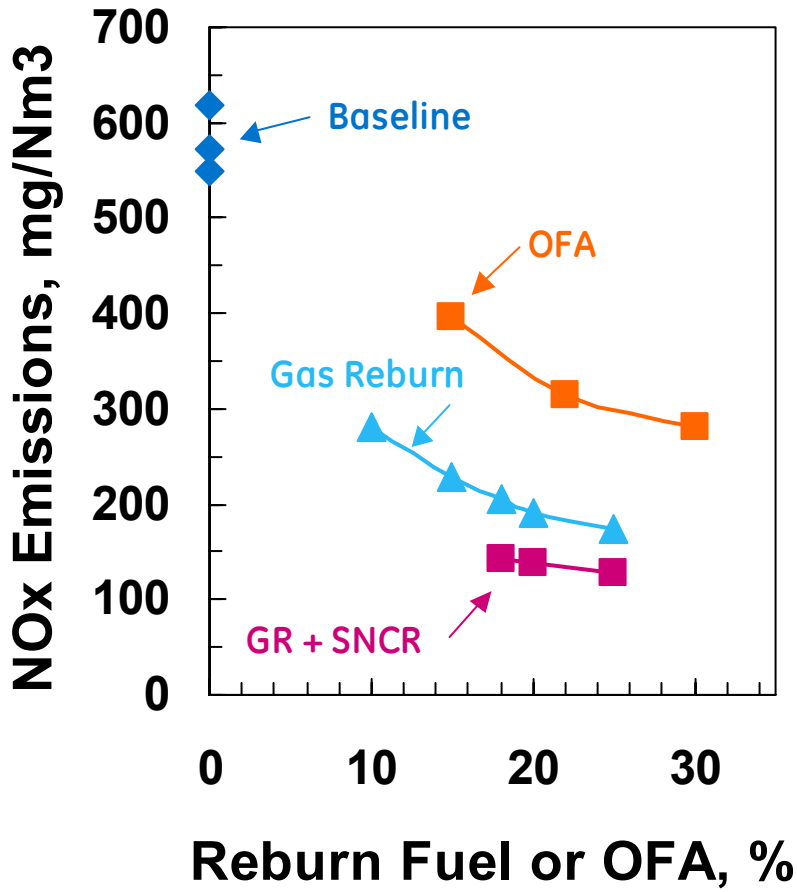
Performance results with low-NOx burners, SOFA, Gas Reburn, & SNCR



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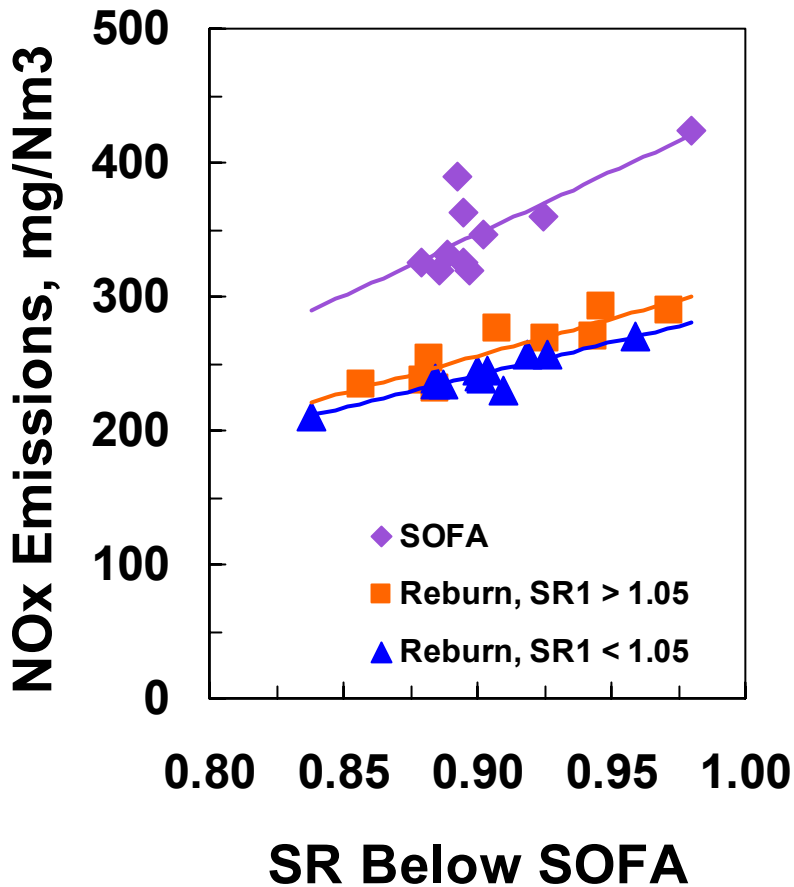
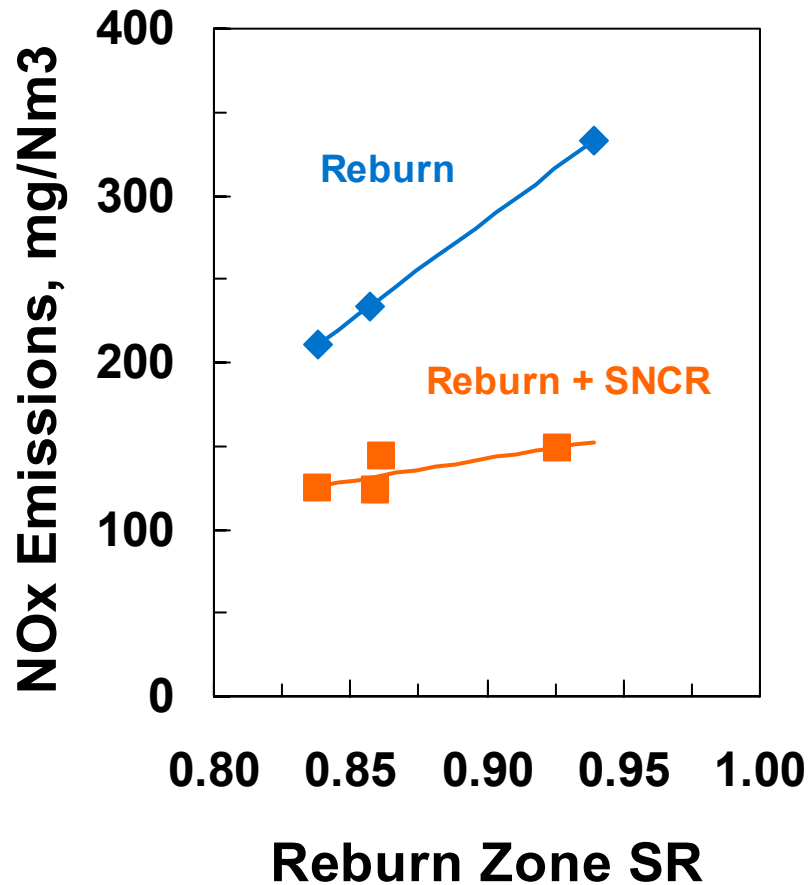
Impacts of SOFA, Reburn, & SNCR on NOx emissions





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Summary

Layering of combustion modification technologies (low-NOx burners, overfire air, Reburn), with SNCR trim, provides a cost-effective approach to NOx emissions control.

Reburning with either natural gas or coal is effective for coal-fired boilers.

Layering of NOx emissions control technologies can permit both short term and long term regulatory compliance.