Advanced Layered Technology Approach (ALTA) for NOx Reduction

For Energy and Environmental Solutions

REACTION ENGINEERING INTERNATIONAL

Hot Topic Hour

Coal-fired Power Plant NOx Reduction Innovations

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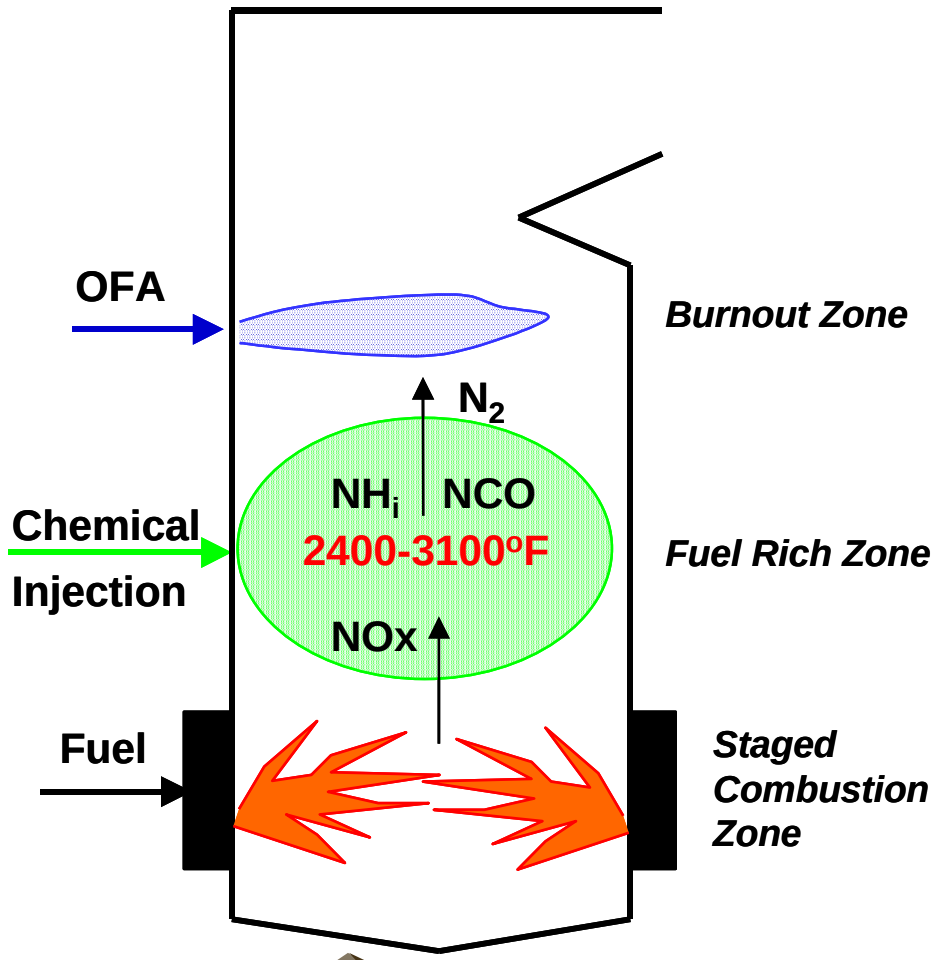
NOx Emissions
Don't SCRs Solve This Problem?

- Cost
  - Power producer goal is not "lowest NOx"; goal is emissions compliance at lowest cost
  - High capital cost for small units
- Catalyst blinding for some coals

Advanced in-furnace controls can be more economically attractive in some cases

Rich Reagent Injection (RRI)

- Staging creates hot, fuel rich lower furnace
- NH_3/urea accelerate the rate of NO_x reduction under reducing conditions
- Insignificant NH_3 slip
- Developed by REI and EPRI
- Fuel Tech, CCA, and FERCo are licensed implementers



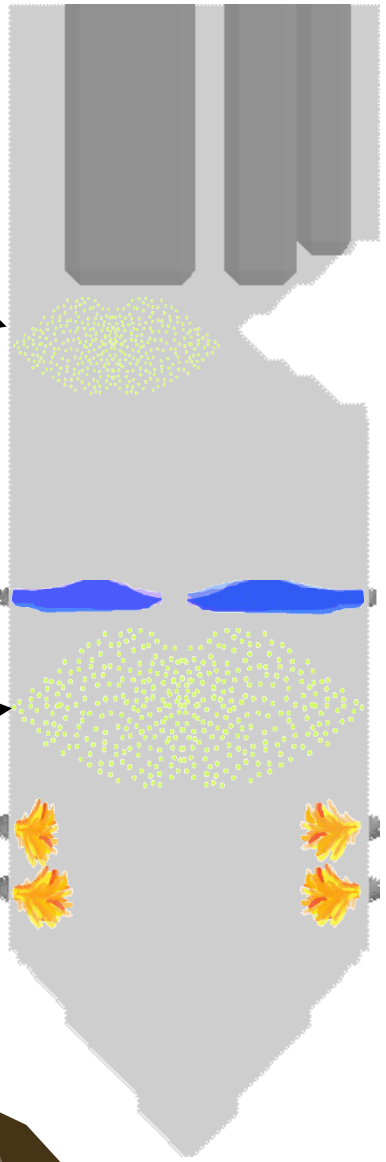
Advanced Layered Technology Approach (ALTA)

SNCR
-Enhanced by reduced stratification

OverfireAir
- Rapid mixing with relatively unstratified combustion products

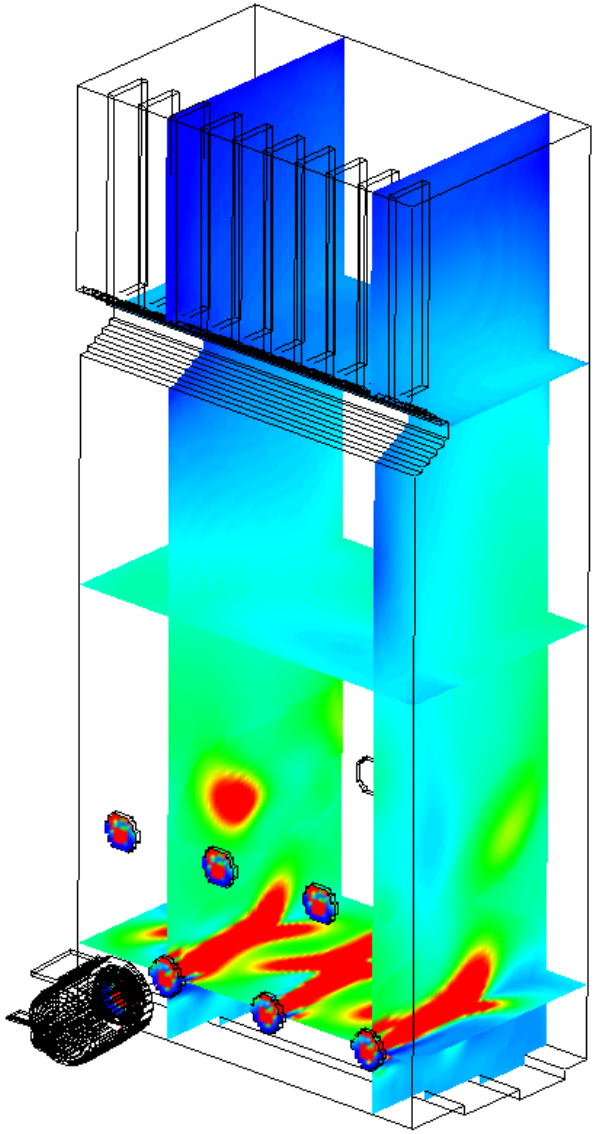
Rich Reagent Injection
-Urea accelerates rate of NO_x reduction

Homogenizing Burners
-Limited stratification
-Lower furnace SR near optimum



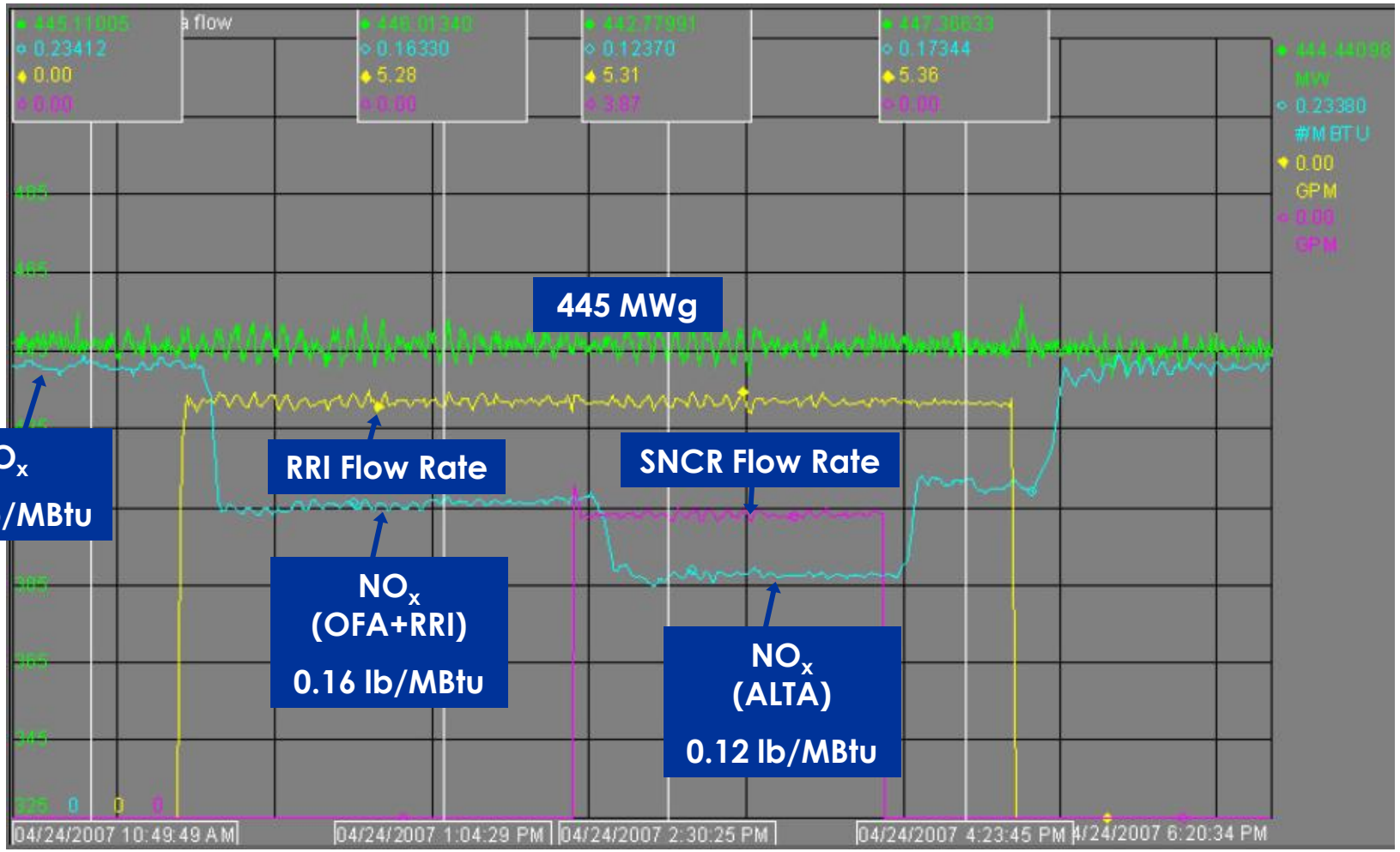
ALTA in Cyclones

- Inherent Advantages for Cyclones
  - Partial combustion in cyclone barrels results in a fuel-rich, relatively well mixed, lower furnace
  - Relatively small furnaces accommodate effective reagent and overfire air mixing
- ALTA installed in 16 cyclone boilers in the US
  - Single and opposed wall-fired boilers
  - 50 MW – 500 MW units
  - CFD based design is critical



ALTA Performance

488 MW Opposed Wall Cyclone



ALTA Economics

50 MW Target Wall Cyclone

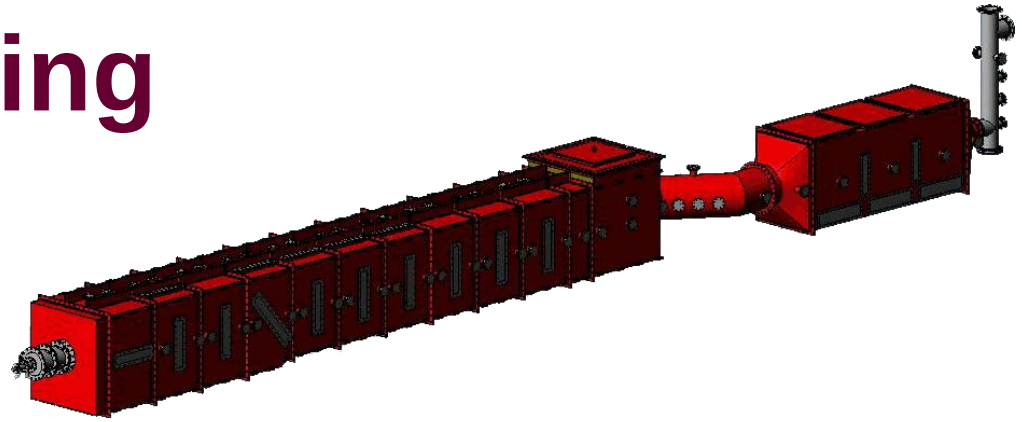
- ALTA is an economically attractive option for NO_x control
  - ALTA installed capital cost = $32.5/kW
  - ~85% lower capital costs vs. SCR
  - ALTA operating costs at Summer 2008 urea prices ($1.76/gal)
    - ~ $900 - $1200/ton NO_x removed (0.7 lb/MBtu baseline)
    - ~55% NO_x Reduction
- Full load control strategy
  - Fixed OFA damper positions
  - Reagent flows: 60 gph for 55% reduction target (NSR~1.7)

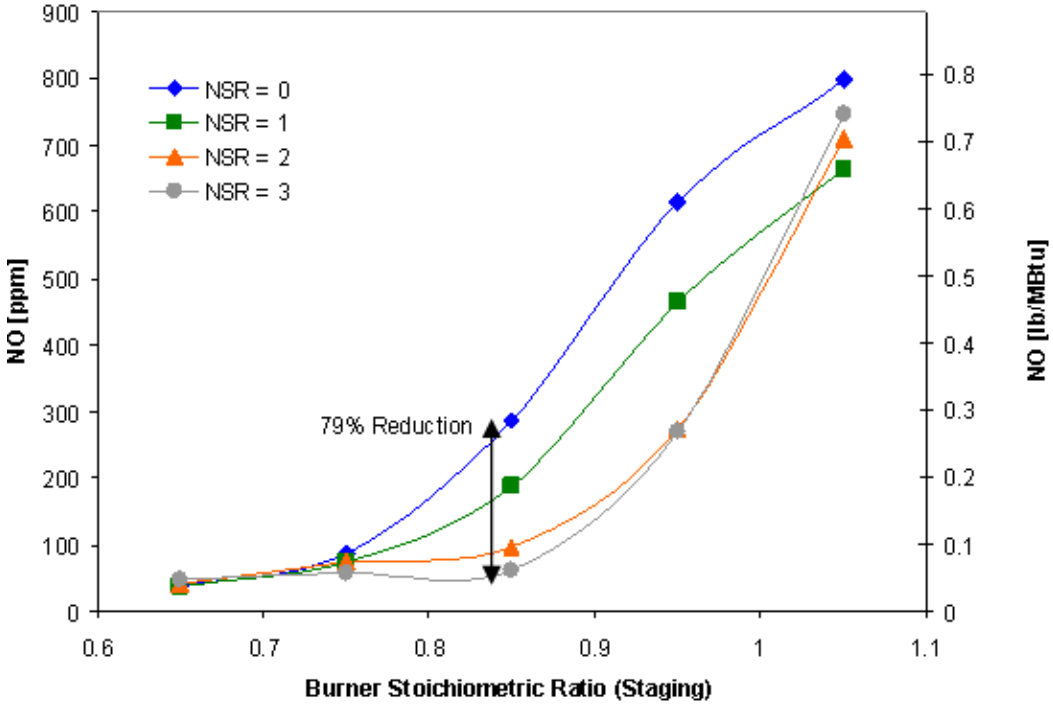
ALTA in PC Units

- DOE funded program to evaluate ALTA approach in pulverized coal units
- Major components
  - Deep staging
  - Optimized burner design for deep staging
  - RRI in fuel-rich zone
- Pilot-scale tests
  - U of Utah
  - 5 MMBtu/hr furnace
- CFD of pilot-scale tests and full-scale unit

Pilot-scale Testing

- PC with conventional low NOx burner design
- NOx as low as 38 ppm, (0.04 lb/MMBtu) under extended residence time
- 79% reduction from RRI at SR_b of 0.85
- Reagent enhancement of NOx reduction kinetics irrelevant at $SR_b < 0.75$

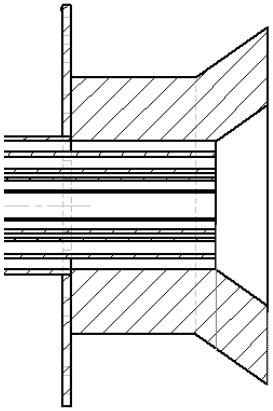




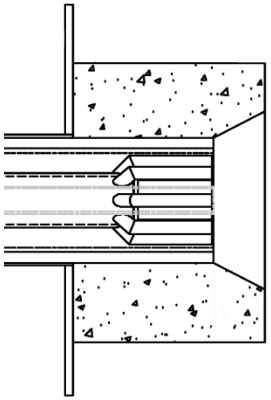
Rapid Homogenization Burner

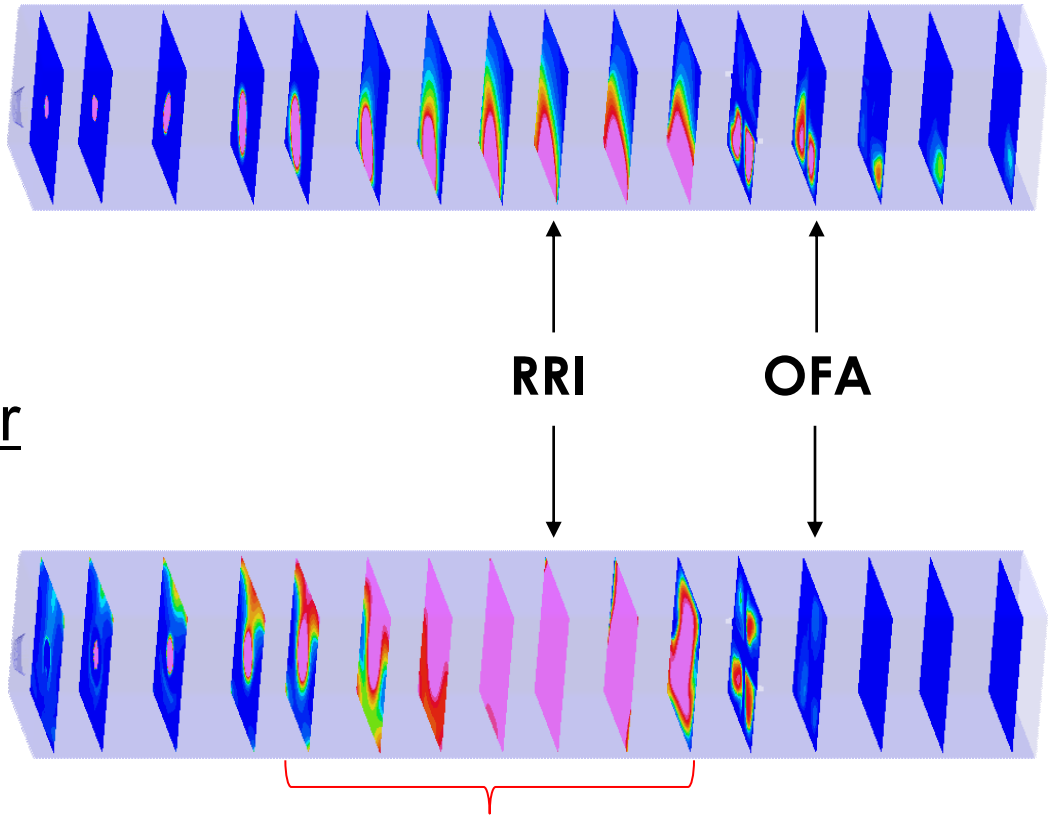
Pilot Scale

Conventional LNB



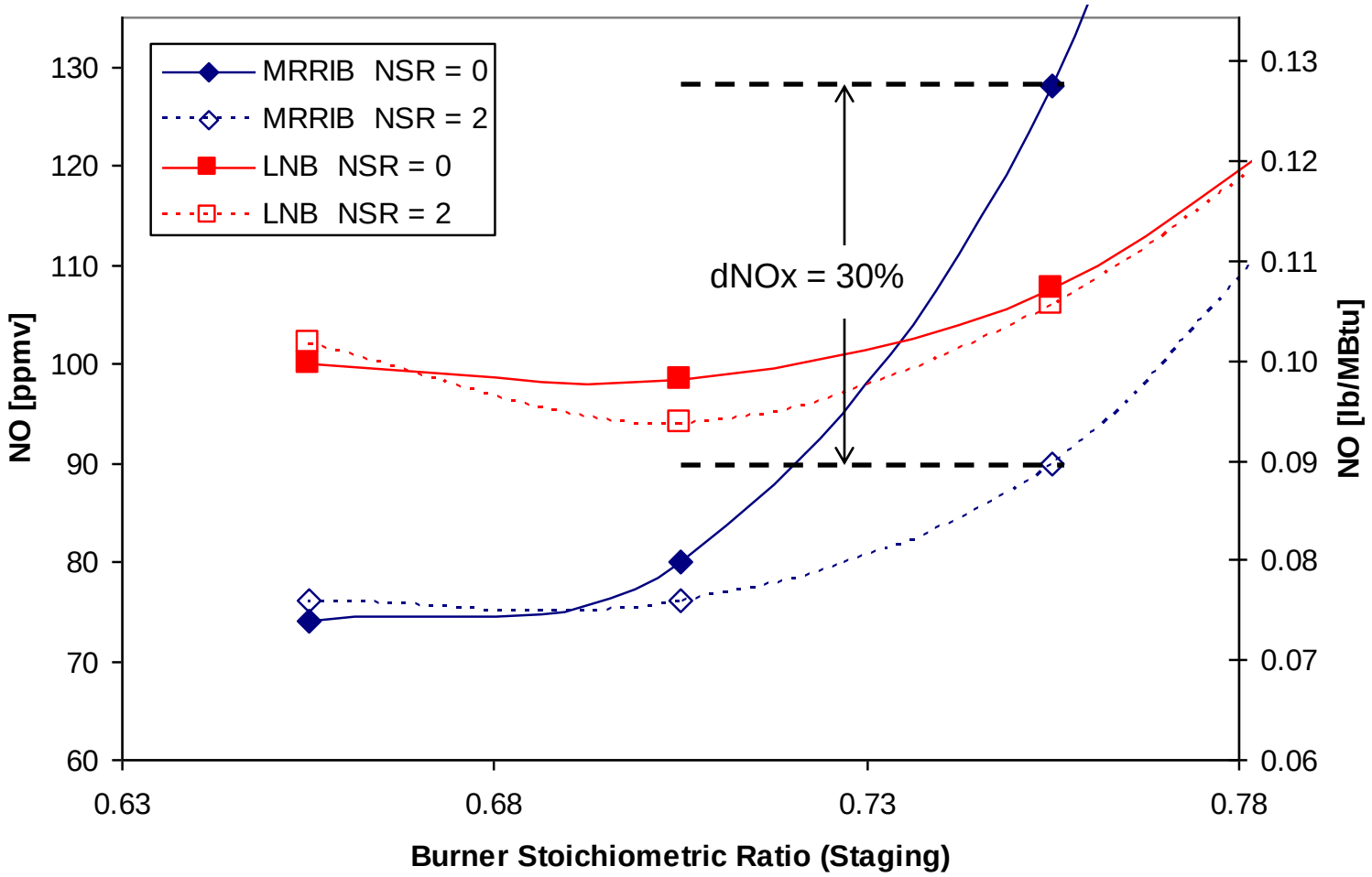
"Homogenizing" Burner





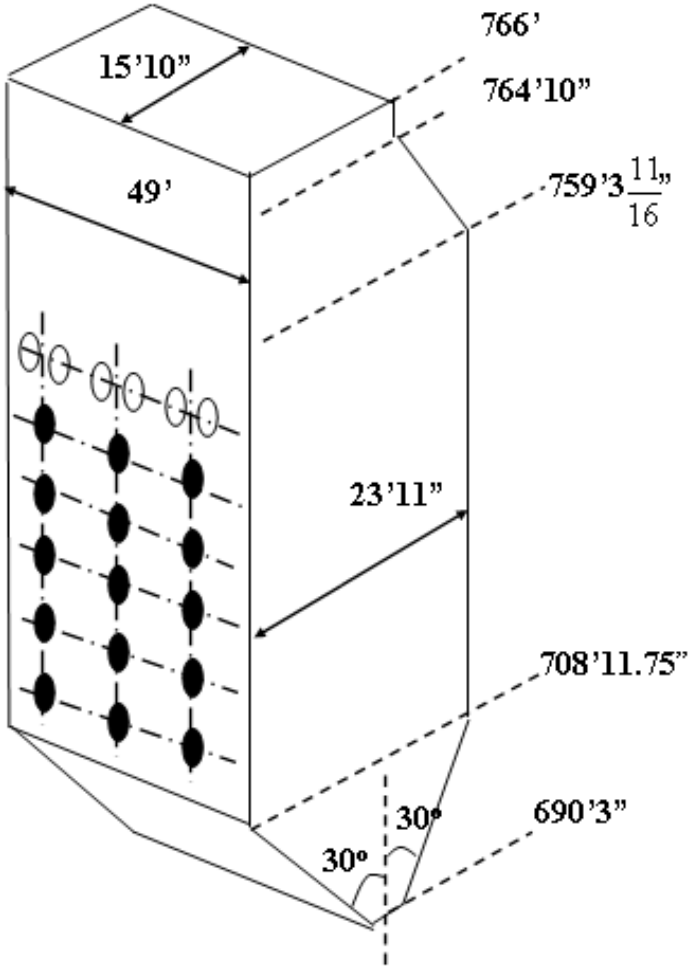
Impacts of Rapid Homogenization Burner

Pilot Scale



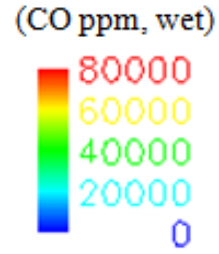
Full-scale Conceptual Implementation

- 180 MW Front-wall-fired boiler using Eastern Bituminous coal
- Previous CFD-based modeling and site testing of RRI indicated < 10% NOx reduction
- Simulations with homogenizing burners to:
  - **Optimize burner stoichiometry**
  - **Guide reagent injection strategy**

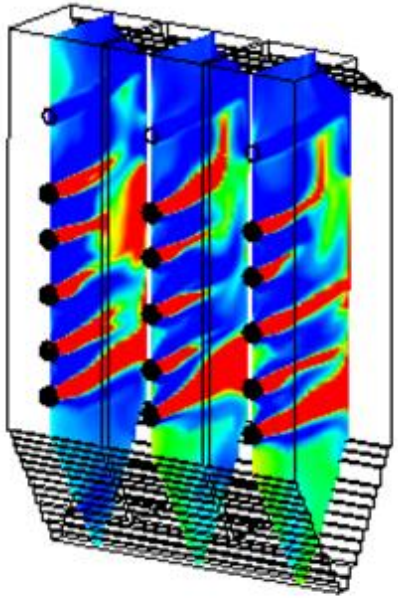


Impacts of “RRI” Burner

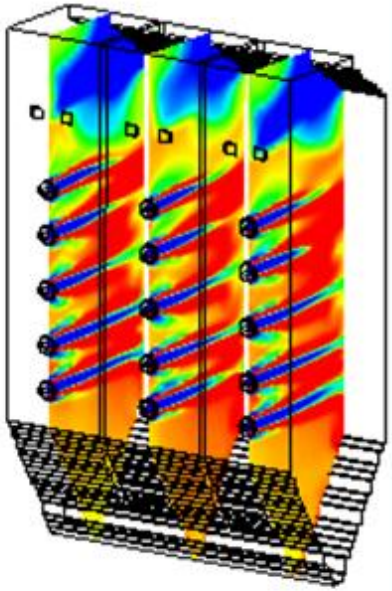
180 MW Boiler



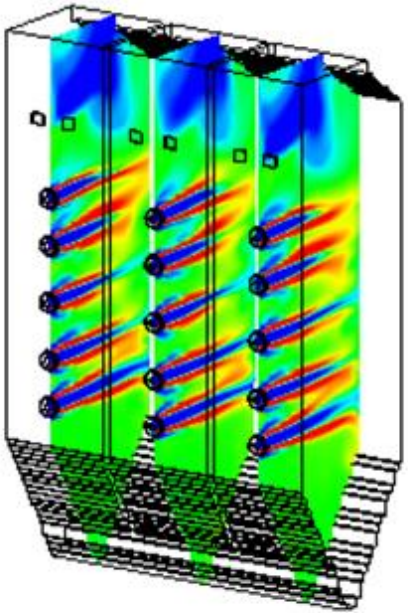
Baseline_SR=0.90



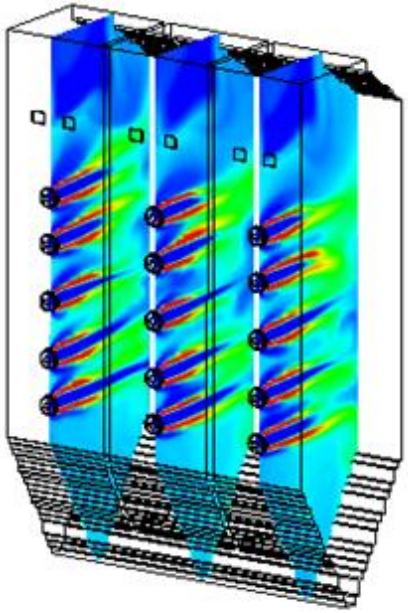
RRIB_SR=0.70



RRIB_SR=0.80



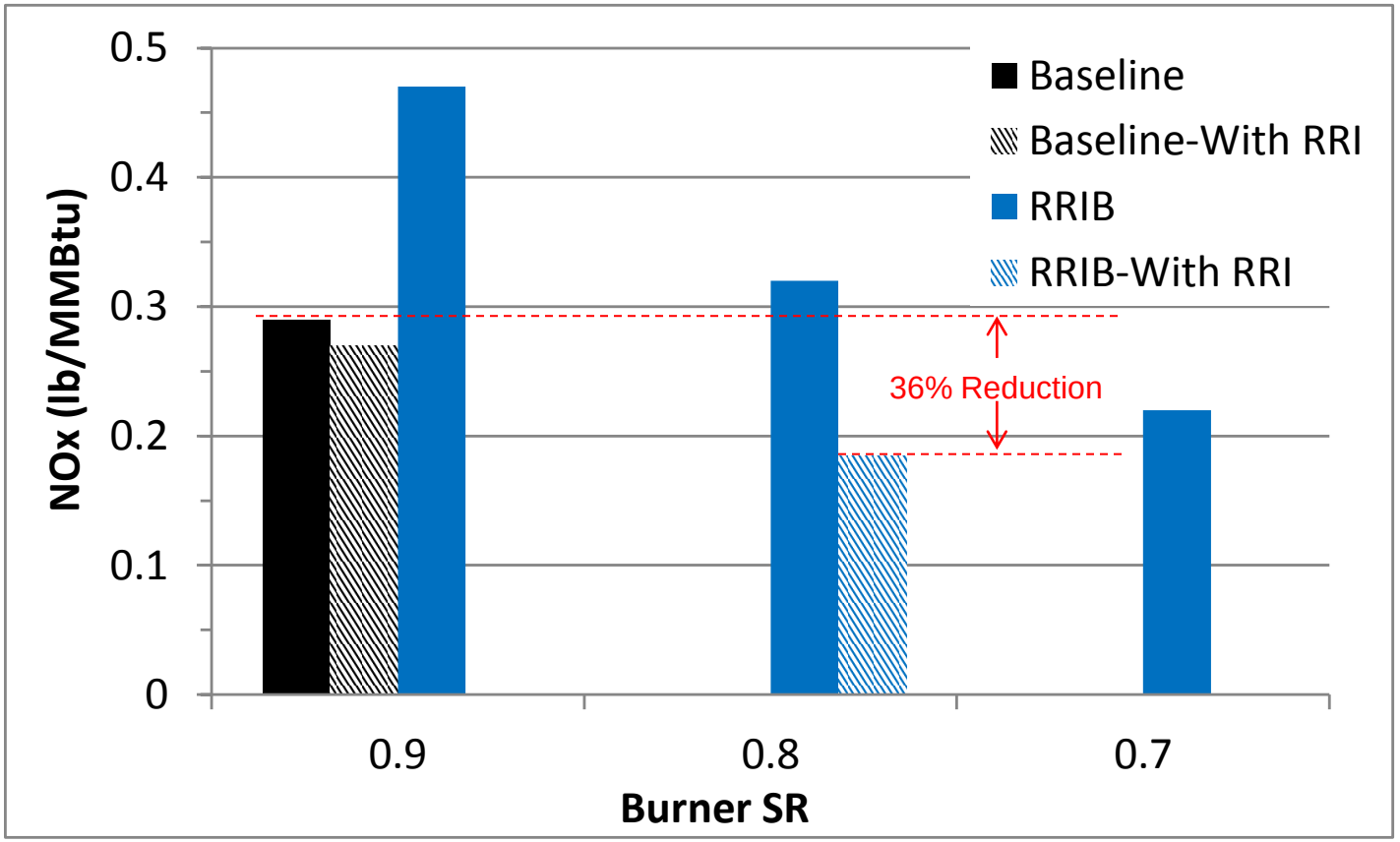
RRIB_SR=0.90



The “RRI” burner homogenizes the lower furnace flue gas

Predicted Full Scale NOx Emissions

180 MW Boiler



The "RRI" burner significantly improves RRI performance and leads to an overall NOx reduction of 36%

Summary

- ALTA in cyclone units
  - Implemented in cyclone boilers as a cost effective alternative to SCR
  - Commercially installed and operated in 16 cyclone boilers to-date
- ALTA in PC units
  - Pilot-scale testing and CFD modeling of a 180 MW coal boiler show that RRI can produce significantly lower NOx emissions than conventional LNB approaches
  - RRI performance in PC units relies on LNB technology optimized for deep staging
- ALTA leverages use of common reagent equipment in RRI and SNCR processes
- RRI, a key ALTA component, is an EPRI owned technology