



# **Improved RRI Performance for NO<sub>x</sub> Control in Coal Fired Utility Boilers**

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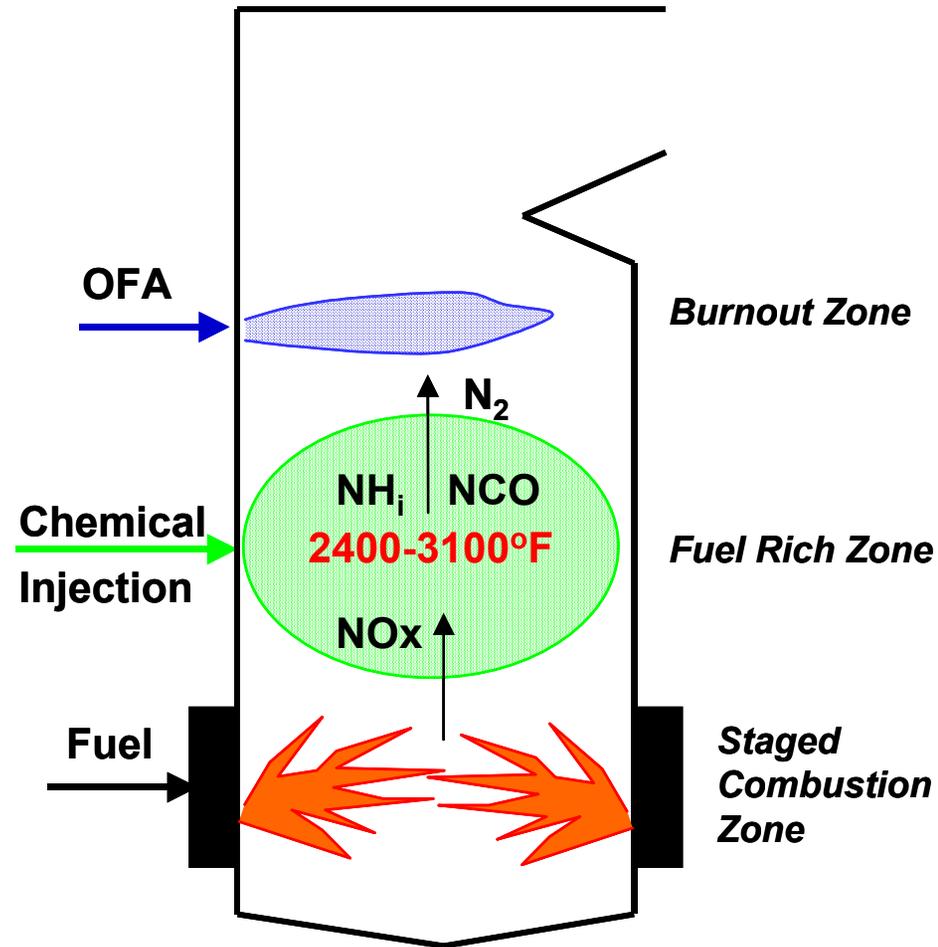


# Presentation Outline

- RRI Background
  - Measured performance
  - Impact of “deeper staging”
- Potential in other units
  - Edgewater Unit 4
  - 205 MW cyclone
- RRI Operating Costs
- Summary

# RRI Background

- High temperature, fuel-rich conditions
- Synergism with staging and RRI
- Avoids ammonia slip
- Potential for <math><0.15</math> lb/MBtu in cyclones
- Co-developed by REI and EPRI





# Demonstration Results

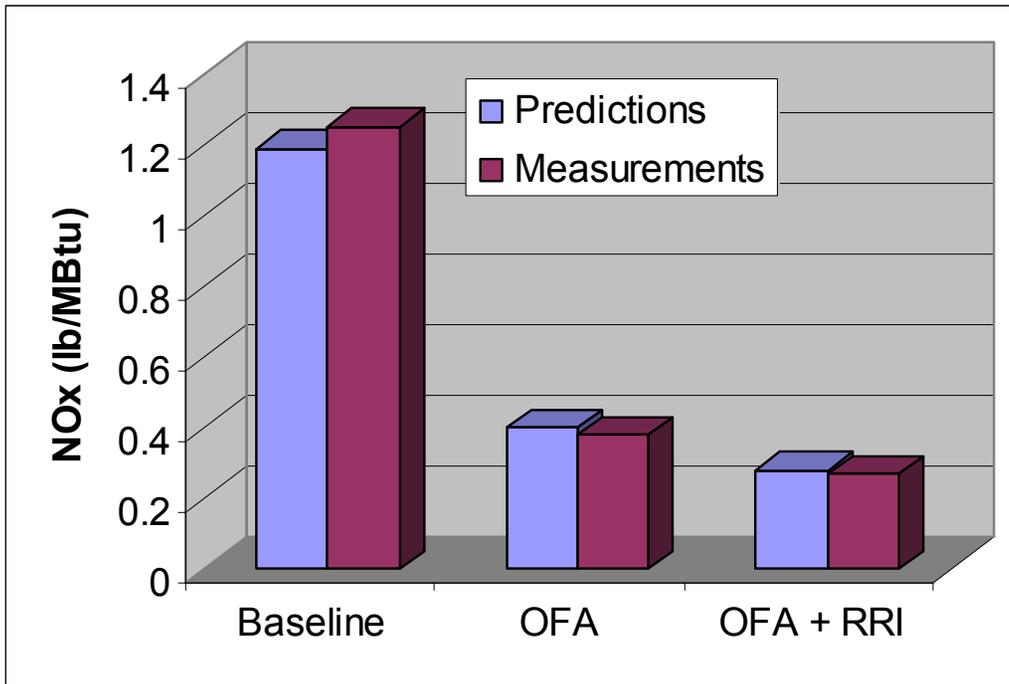
## ➤ **BL England Unit 1 (Conectiv)**

- 130 MW cyclone, 0.55 lb/MBtu
- RRI: 30% NO<sub>x</sub> reduction, <1 ppm NH<sub>3</sub>
- RRI+SNCR: 55% NO<sub>x</sub> reduction, <5 ppm NH<sub>3</sub>

## ➤ **Sioux Unit 1 (AmerenUE)**

- 500 MW cyclone, 0.38 lb/MBtu
- RRI: 30% NO<sub>x</sub> reduction, <1 ppm NH<sub>3</sub>
- Sensitivity to barrel SR

# As Good As it Gets?



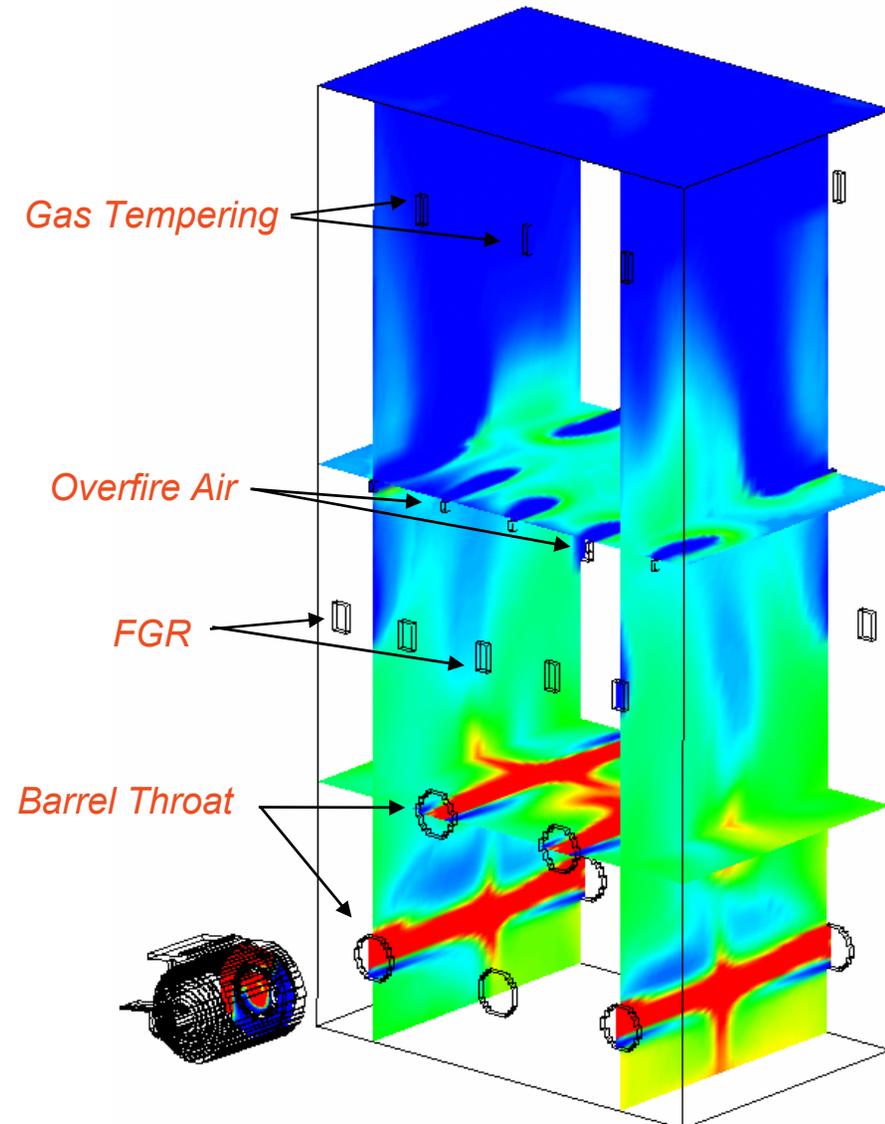
## Sioux Unit 1 Results

- RRI+OFA: 0.27 lb/MBtu
- Predictions consistent with measurements
- Can RRI do better in Sioux?
- Other units?

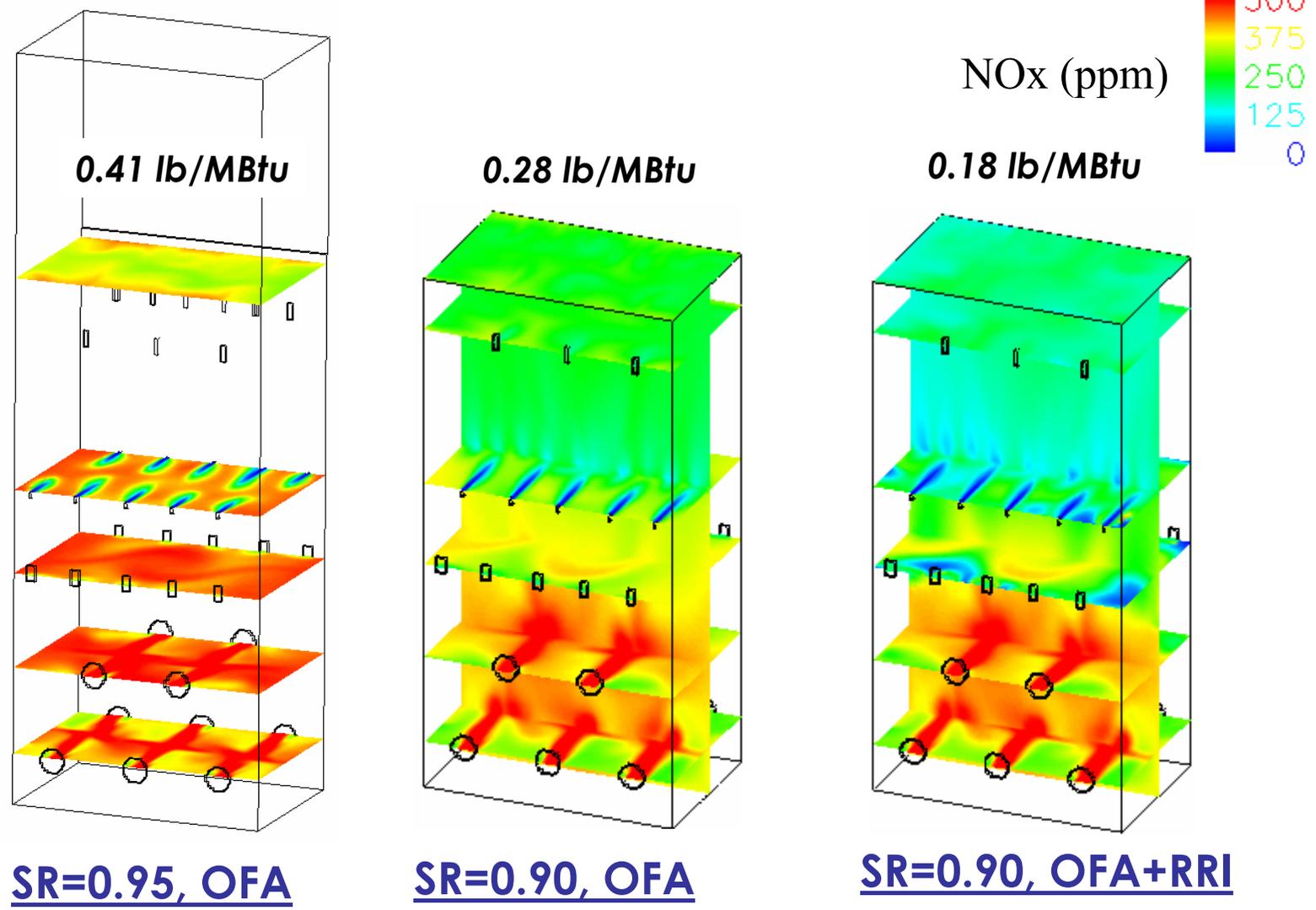
- What NOx emissions can be expected by combining RRI with “deeper staging?”
- Can better NOx reductions be achieved with RRI in other units?

# CFD Model Approach

- Cyclone Barrel
- Lower Furnace  
OFA
- Lower Furnace  
OFA + RRI
  - 20 RRI ports
  - 6 on each side wall
  - 4 each on front  
and rear walls



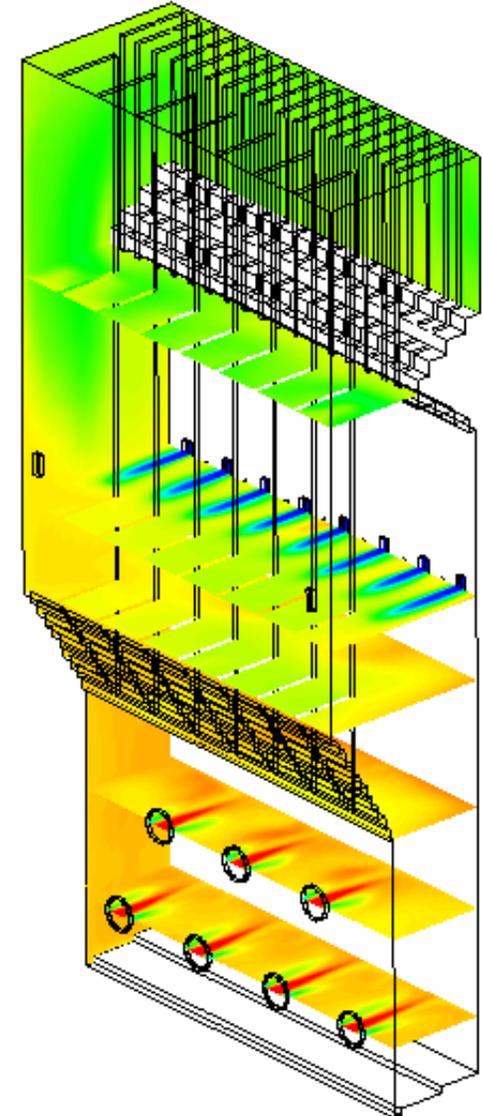
# RRI in Sioux Unit 1 500 MW Cyclone



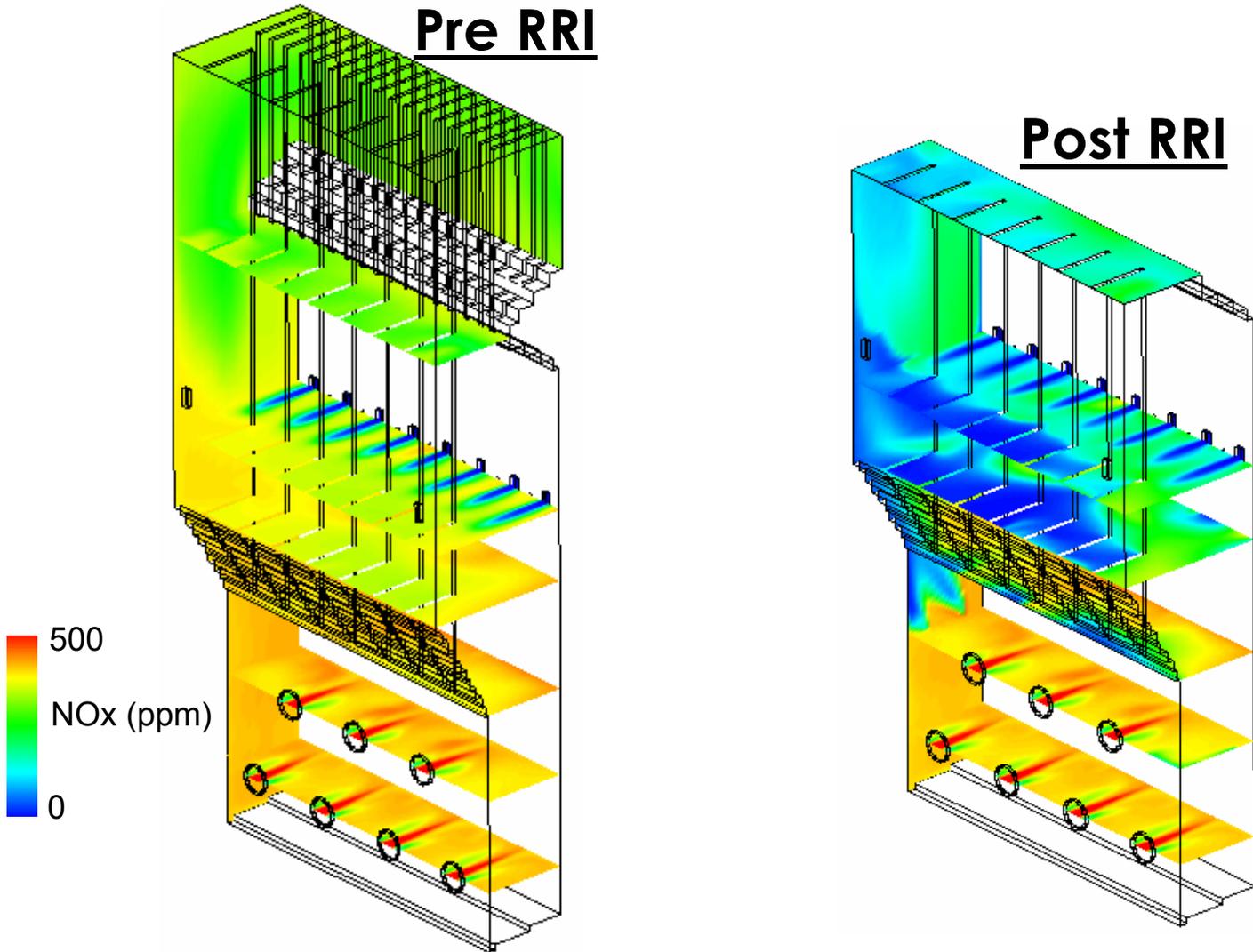
# Edgewater Unit 4

## Alliant Energy

- 330 MW, seven barrels, single wall-fired
- SmartBurn<sup>SM</sup> technology
- Front and Rear Wall OFA
- PRB/Bituminous blend
- NO<sub>x</sub>
  - 0.45 lb/MBtu
  - <0.30 lb/MBtu measured under "deeper staging"

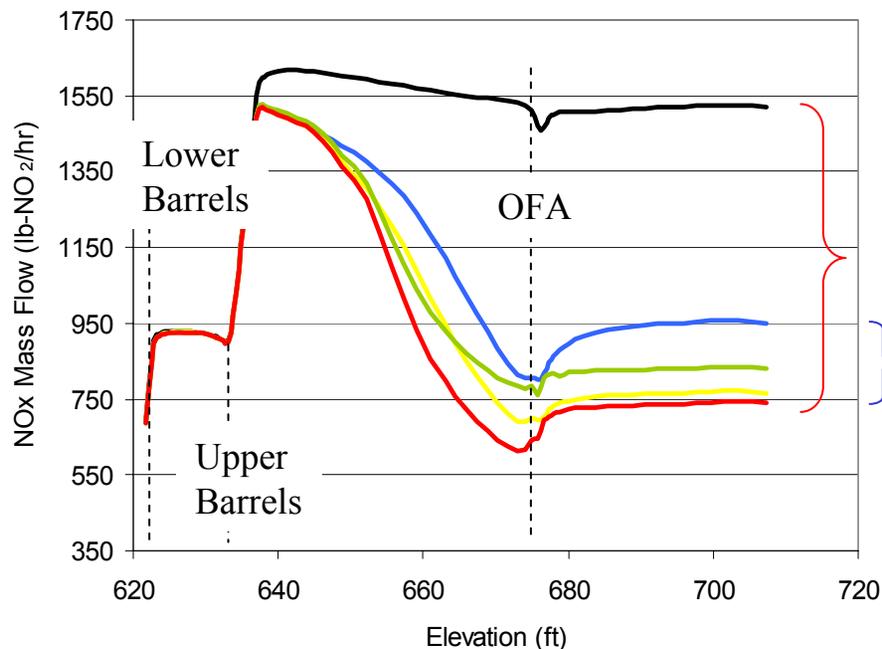


# RRI Evaluation Edgewater Unit 4



# Predicted RRI Performance Edgewater Unit 4

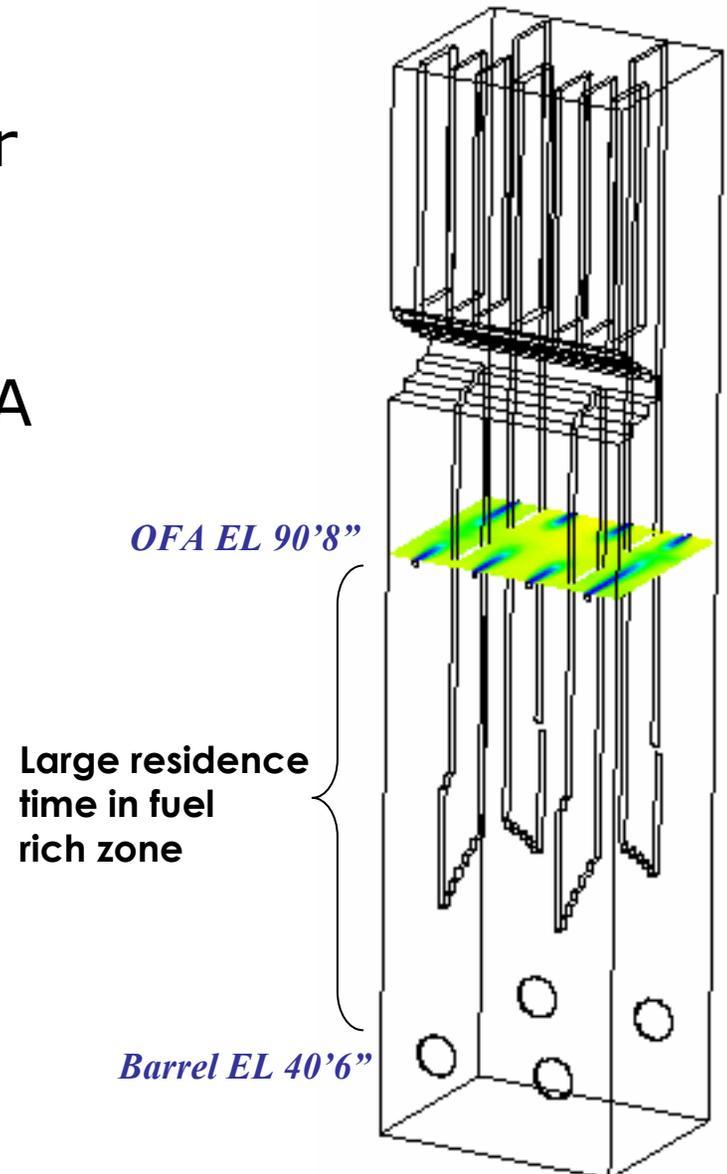
— Baseline — RRI 1 — RRI 2 — RRI 3 — RRI 4



- 52% NO<sub>x</sub> reduction to 0.22 lb/MBtu, <1 ppm NH<sub>3</sub> slip
- <0.15 lb/MBtu expected when RRI is combined with "deeper staging"

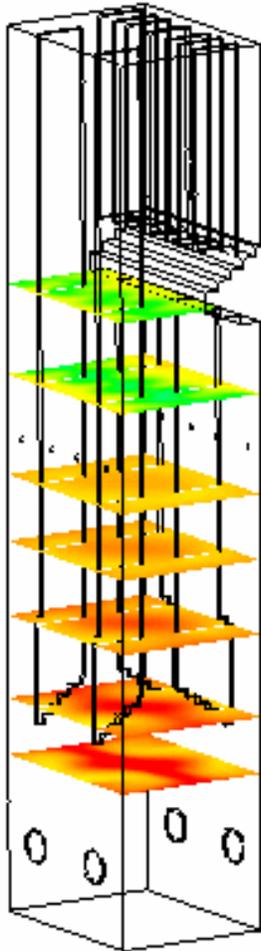
# 205 MW Cyclone

- Opposed wall-fired, four scroll burner barrels
- Front and Rear Wall OFA
- Bituminous Coal
- Large residence time
- $\text{NO}_x \sim 0.6 \text{ lb/MBtu}$ 
  - 1.2 lb/MBtu prior to OFA

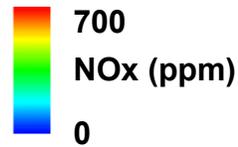
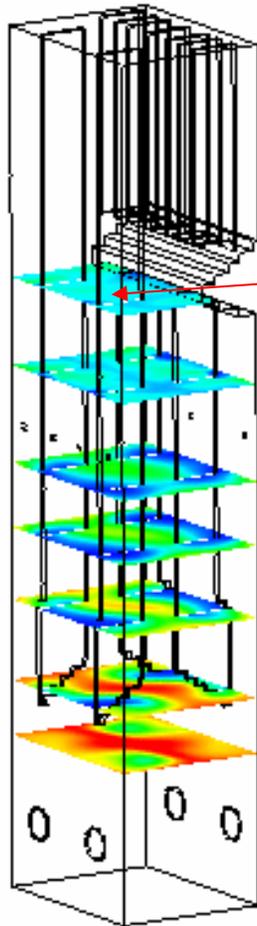


# Predicted Performance 205 MW Cyclone

Pre RRI

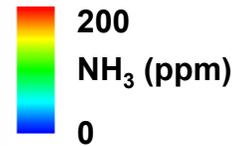
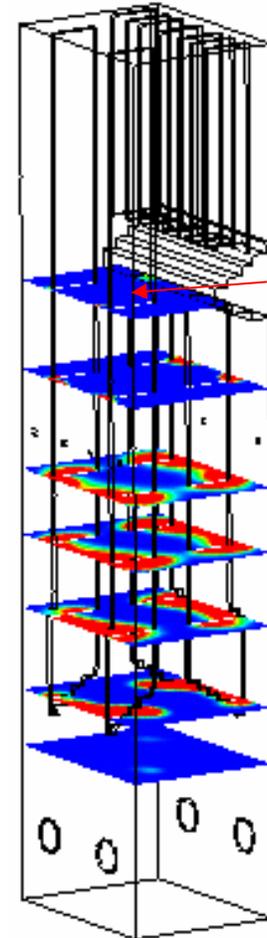


Post RRI



57% NOx reduction  
from 0.61 lb/MBtu  
full load baseline

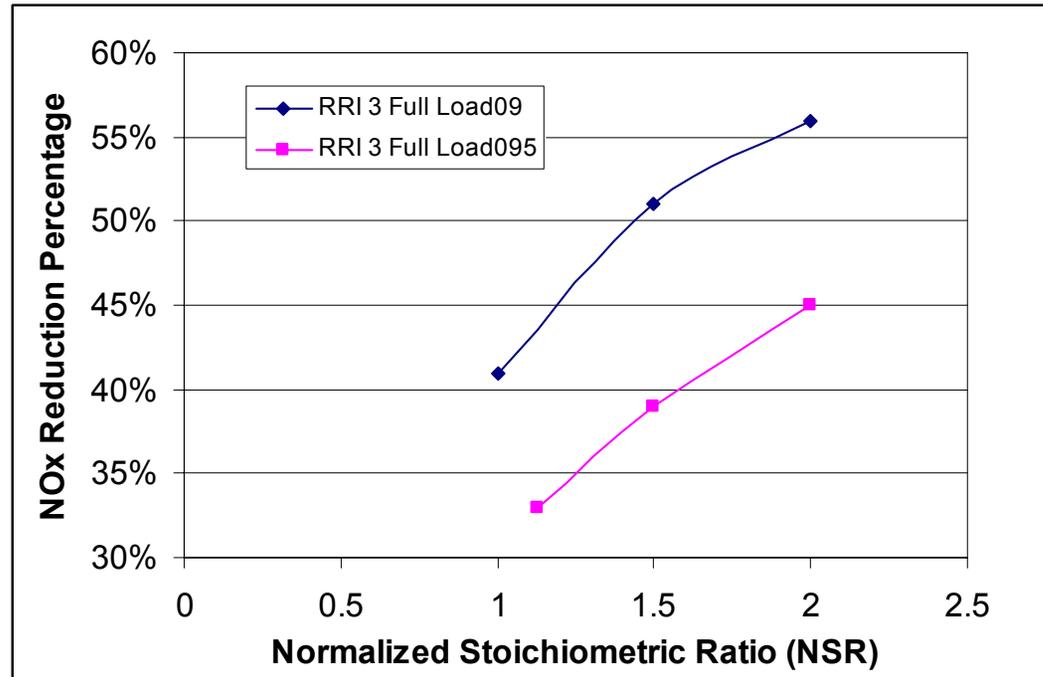
Post RRI



< 1 ppm NH<sub>3</sub>

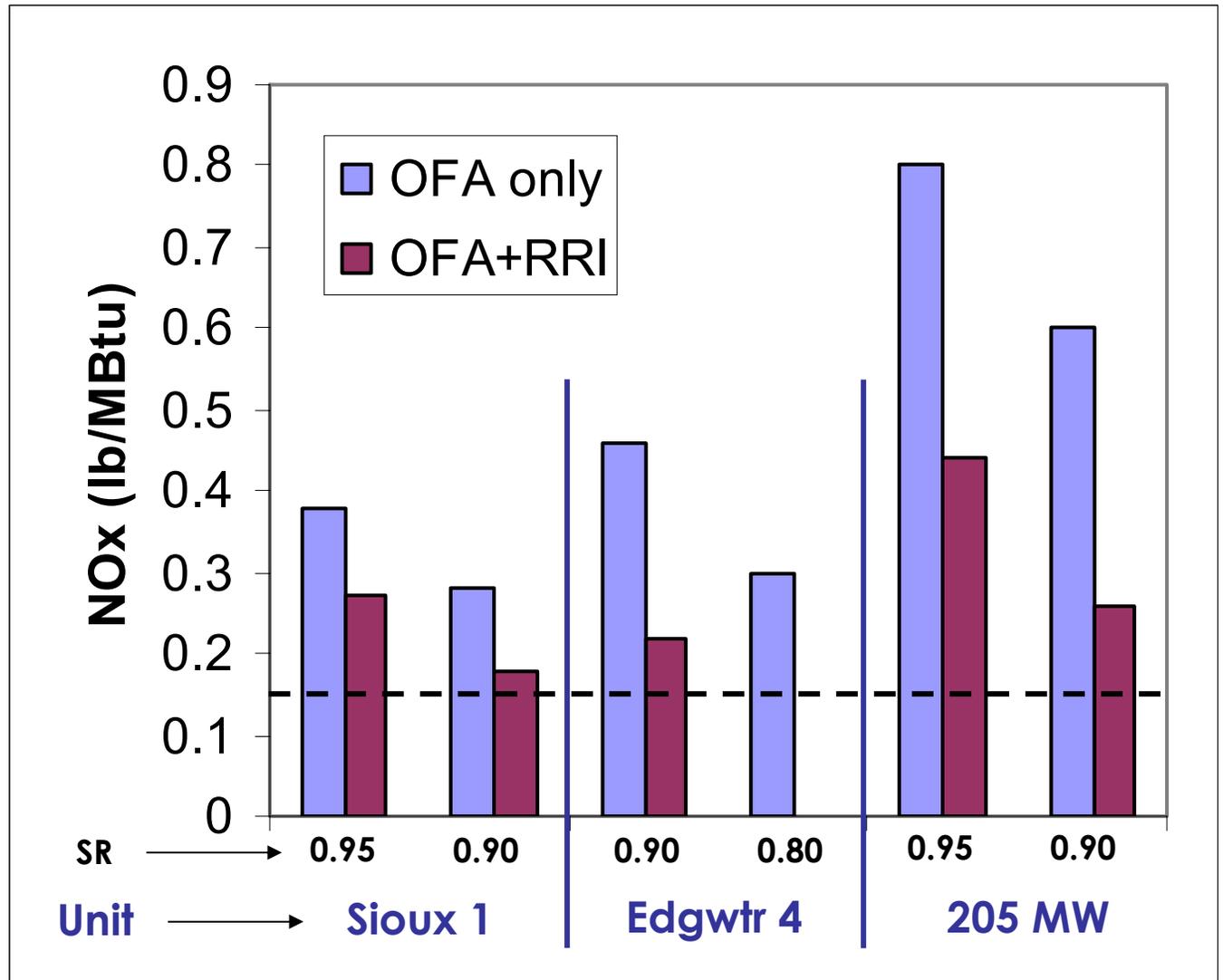
# NSR Dependence

## RRI in 205 MW Cyclone



- 41% reagent utilization at NSR=1
- RRI performance increases with staging level
- 57% NO<sub>x</sub> reduction to 0.26 lb/MBtu at NSR=2
- Best performance with 12 injectors at two elevations

# Overall Results

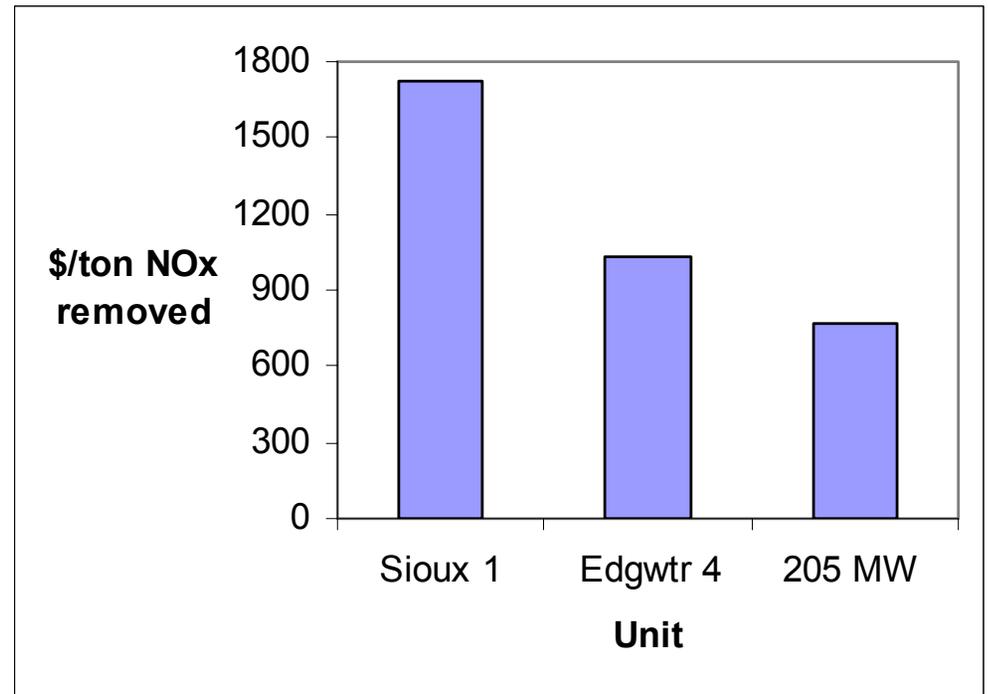




# Approximate RRI Costs

## Reagent Costs

(Assumes \$0.80 per gallon 50% urea)



- Capital Costs consistent with SNCR



# Summary

- RRI combined with deeper staging will likely achieve  $\text{NO}_x < 0.15 \text{ lb/MBtu}$  in certain cyclone boilers
- Combined with SNCR,  $\text{NO}_x < 0.15 \text{ lb/MBtu}$  likely achievable in many cyclone boilers
- RRI in staged cyclone boilers having large rich zone residence time will likely achieve  $> 50\%$   $\text{NO}_x$  reduction



# Acknowledgements

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**Thank You!**