Low-NOx Slagging Combustion for a Low Emission Boiler System (LEBS)

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Evolution of Combustion Technology to Support National Energy Needs

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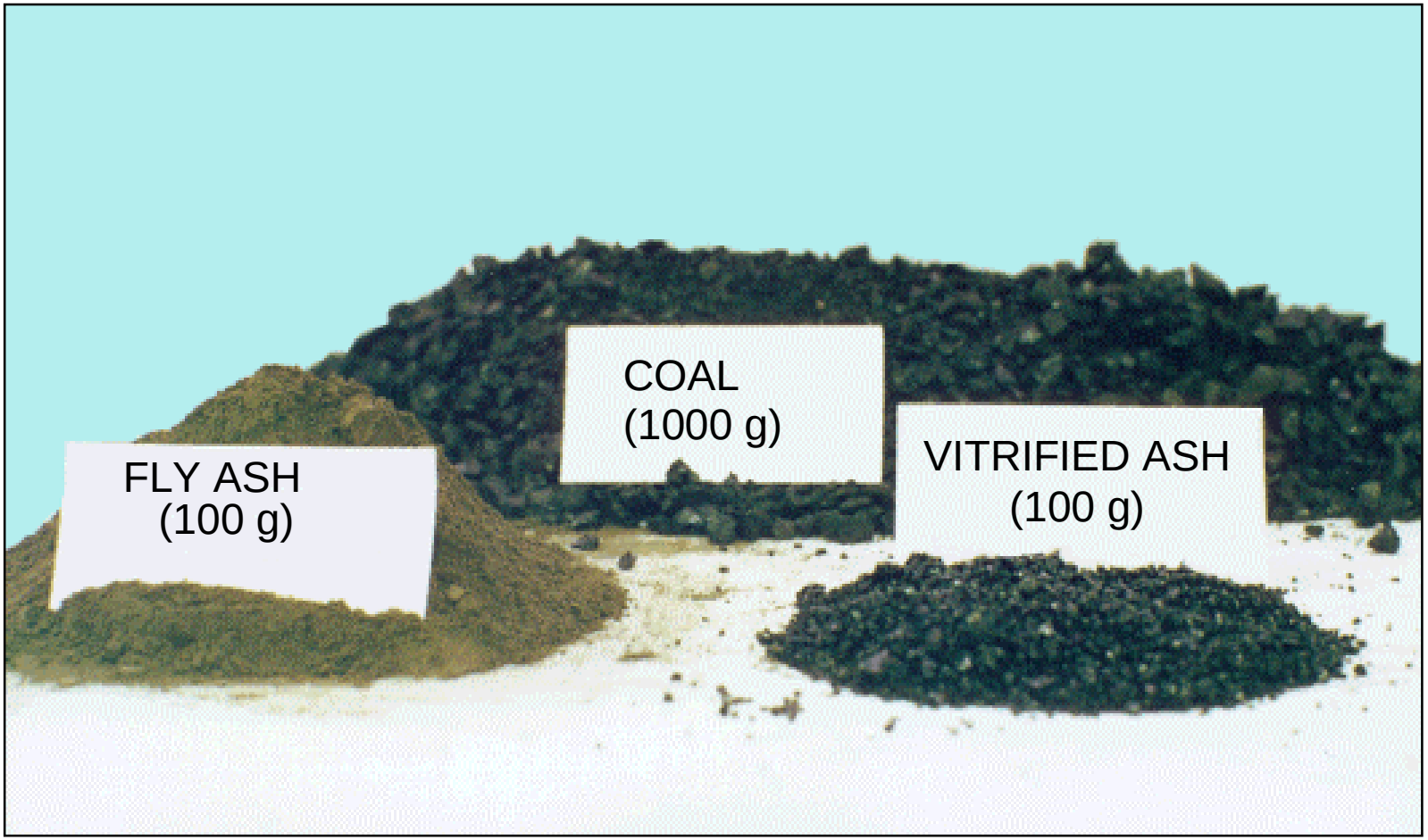
LEBS PROJECT GOALS:

- Ensure a reliable and affordable energy supply with minimum environmental impact
- Lower emissions-
  - NO_X < 0.1 lb/10^6 Btu
  - SO_X < 0.1 lb/10^6 Btu
  - Particulate < 0.01 lb/10^6 Btu
- Eliminate solid wastes
- High Efficiency

Vitrified Ash

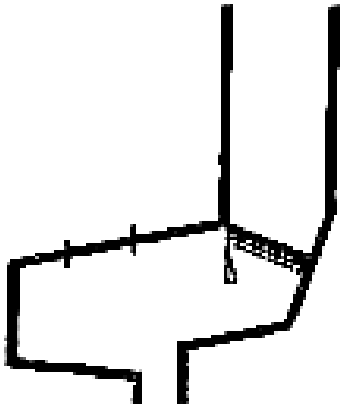
Reduced Volume, Non-leachable, Useful Byproduct



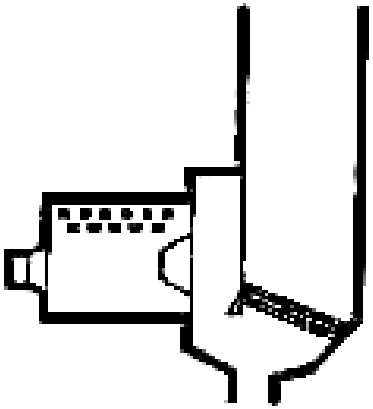
Firing System Objectives

- NO_X < 0.2 lb/10^6 Btu
- produce vitrified ash byproduct
- applicable to wide range of coals
- scalable to central station designs

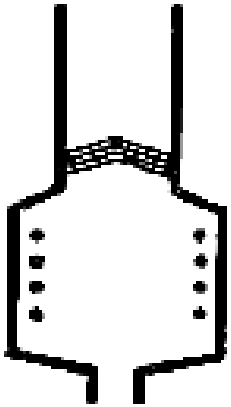
Slag–Tap Furnace Designs



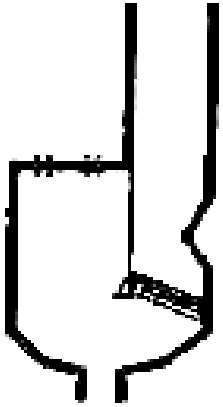
Retort



Cyclone

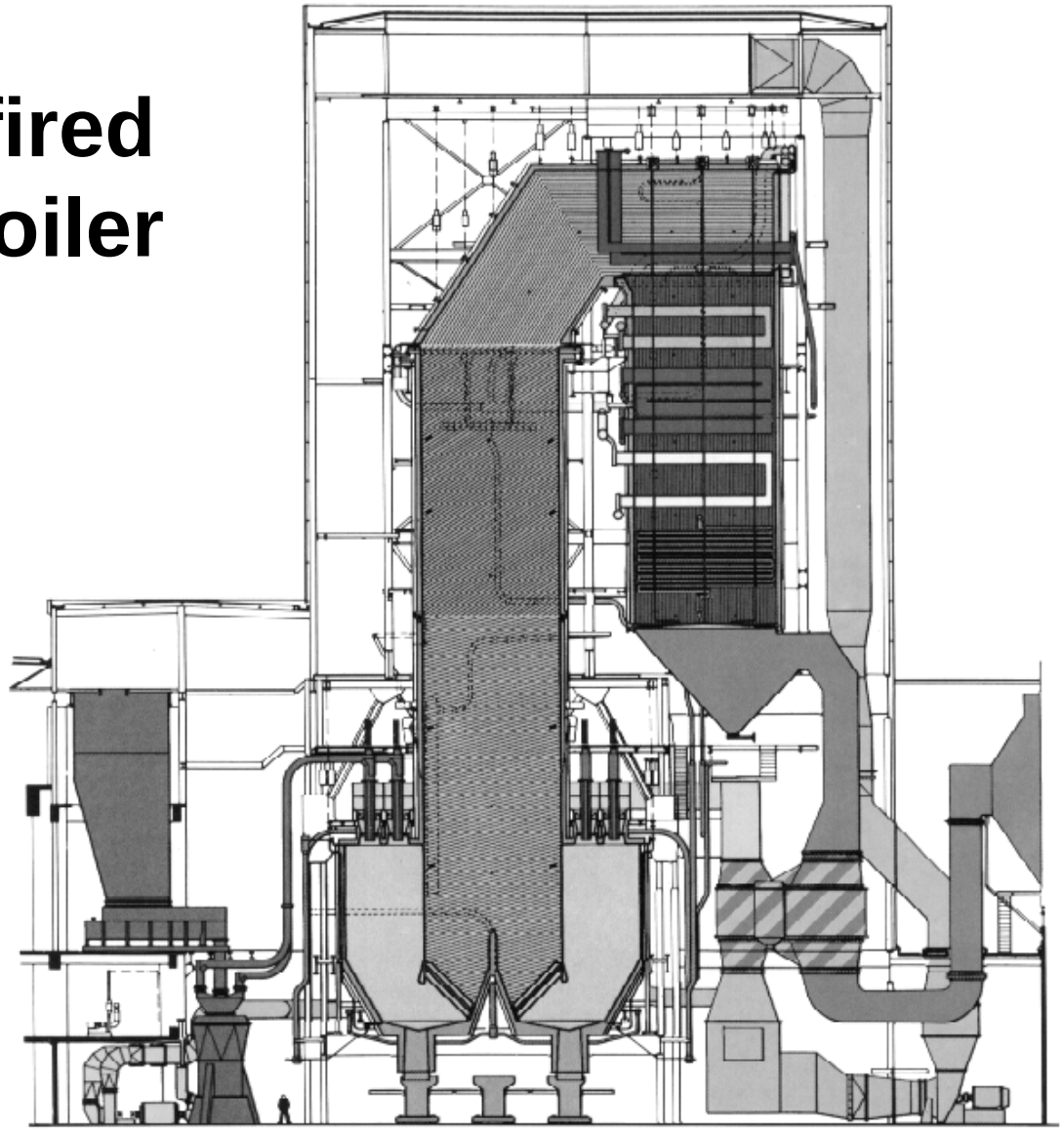


Tangential



U-Fired

320 MW U-fired Slag-Tap Boiler



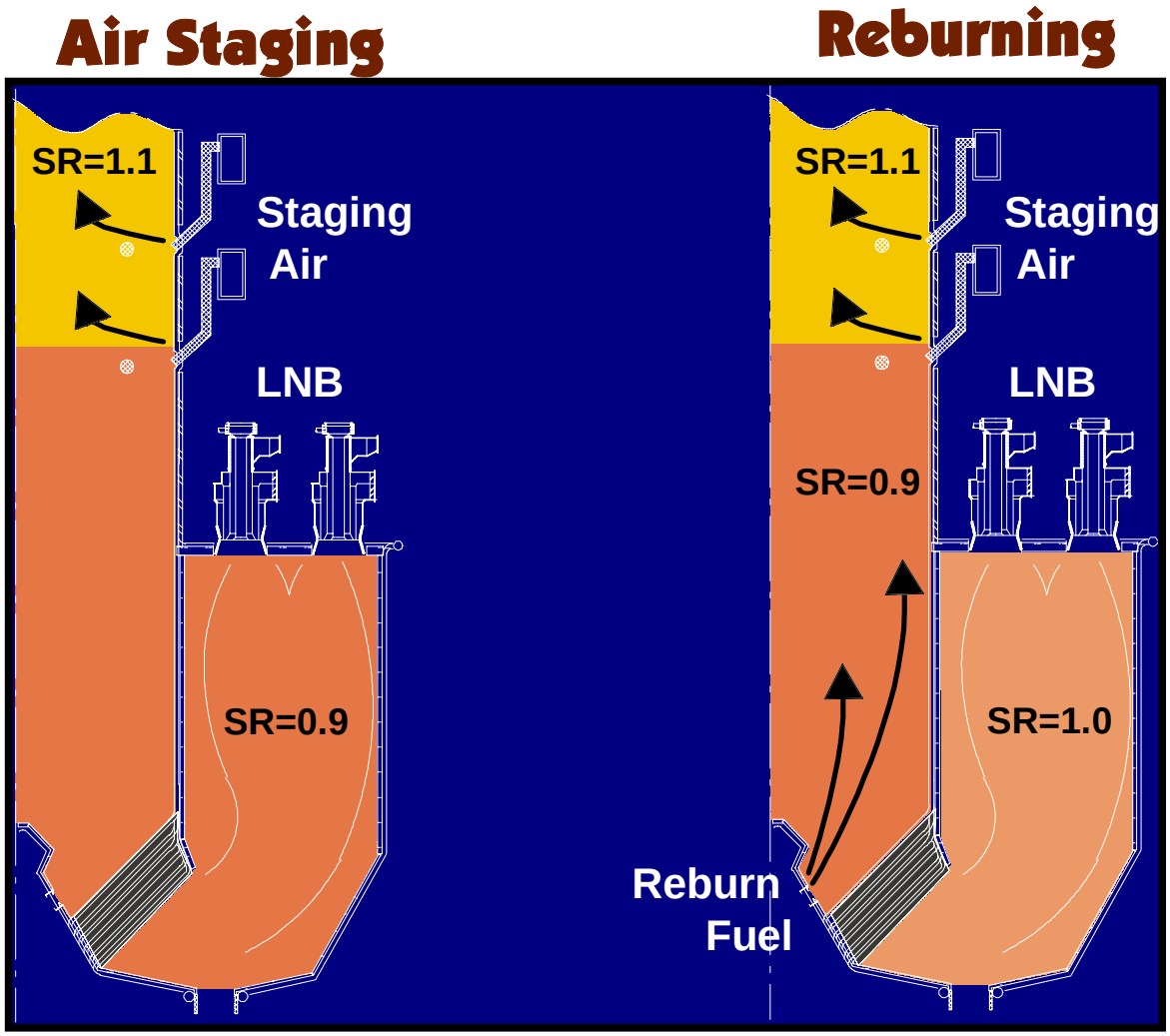
U-Fired Experience Range

Steam capacity, tons/hour	**50-1000**
Design Coal Properties	
Volatile matter,DAF %	**15 - 40**
Ash, as-rcvd. %	**8 – 40**
Moisture, as-rcvd. %	**1 – 31**
LHV, Btu/lb	**6,300 – 12,600**
Slag fluid temperature, ^{o}F	**to 2700**

Low-NOx Combustion System

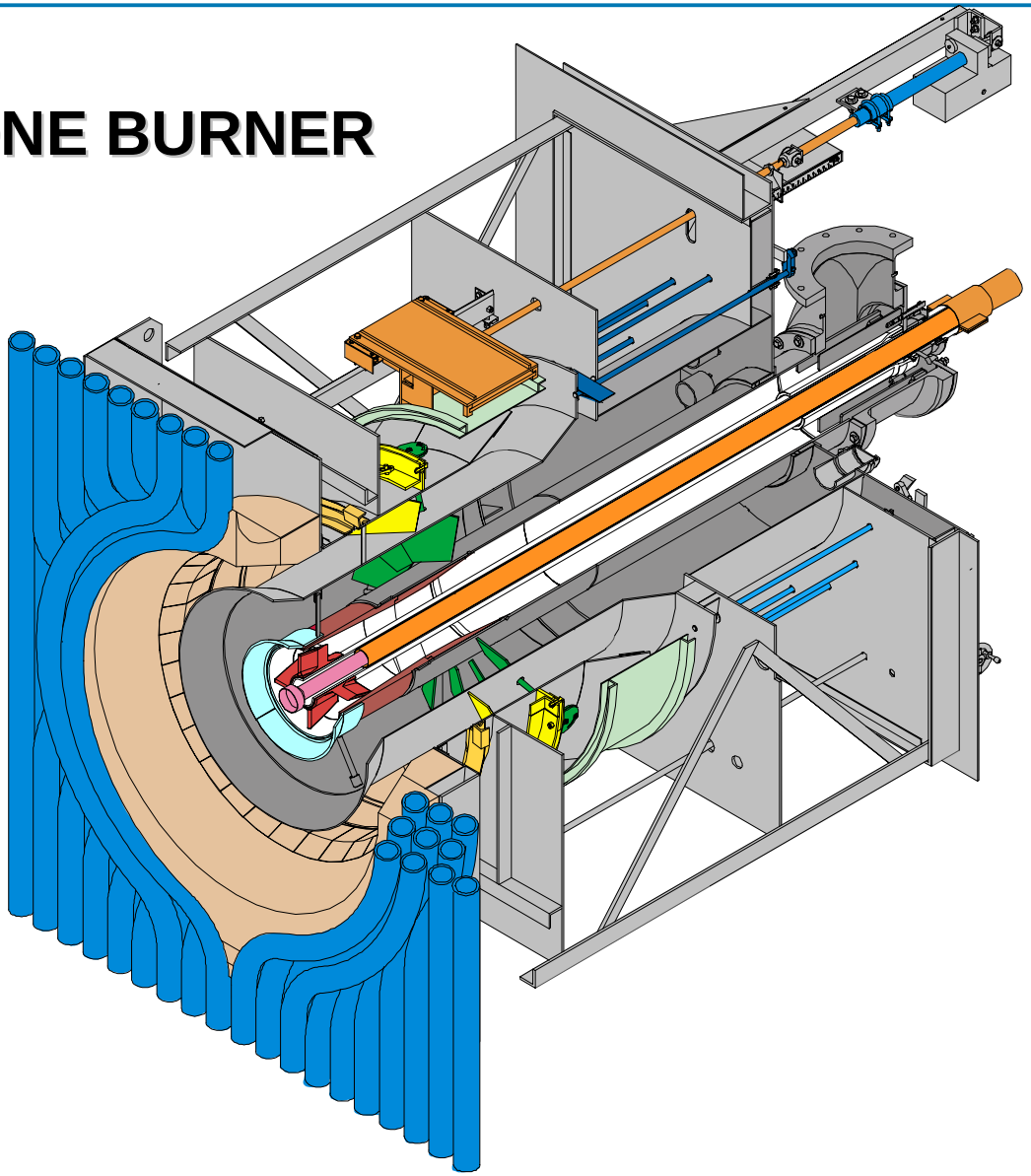
- U –fired Slag Tap Furnace
- Low - NO_X Burners
- Air Staged Combustion
- Coal Reburning

LEBS Firing System

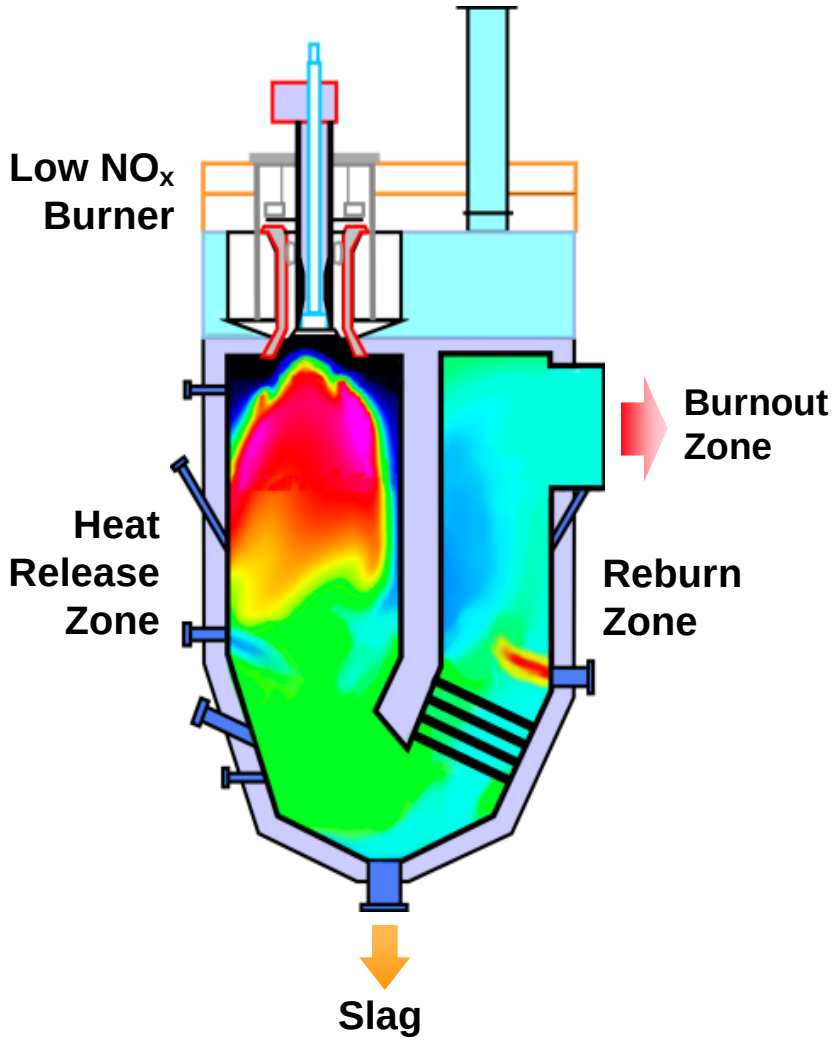


CCV DUAL AIR ZONE BURNER

- Venturi Coal Nozzle
- Secondary/ Tertiary Air Zones
- Air Separation Diverters
- Independent Air Swirl and Flow Control



U-FIRED TEST FACILITY

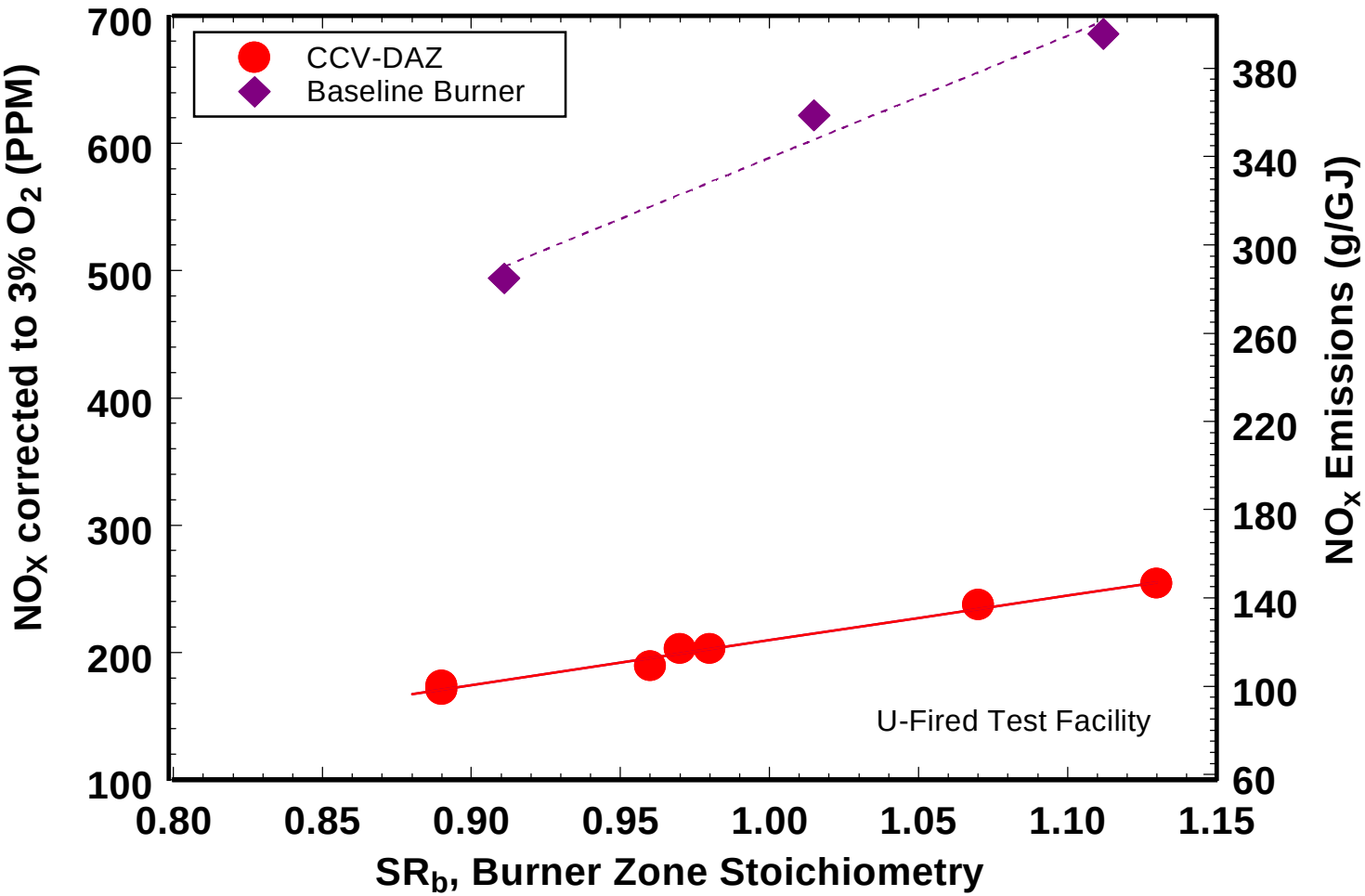


Test Coals

E. Appalachian	Illinois No. 5	Powder River Basin
High Volatile Bituminous A	High Volatile Bituminous C	Sub-Bituminous C
13,220 Btu/lb	10,667 Btu/lb	8930 Btu/lb
FC/VM = 1.89	FC/VM = 1.23	FC/VM = 1.21
2700 ^{o}F *	2240 ^{o}F *	2200 ^{o}F *
1.35 %S	3.15 %S	0.32 %S

*** Fluid; Reducing**

U-Fired Test Results

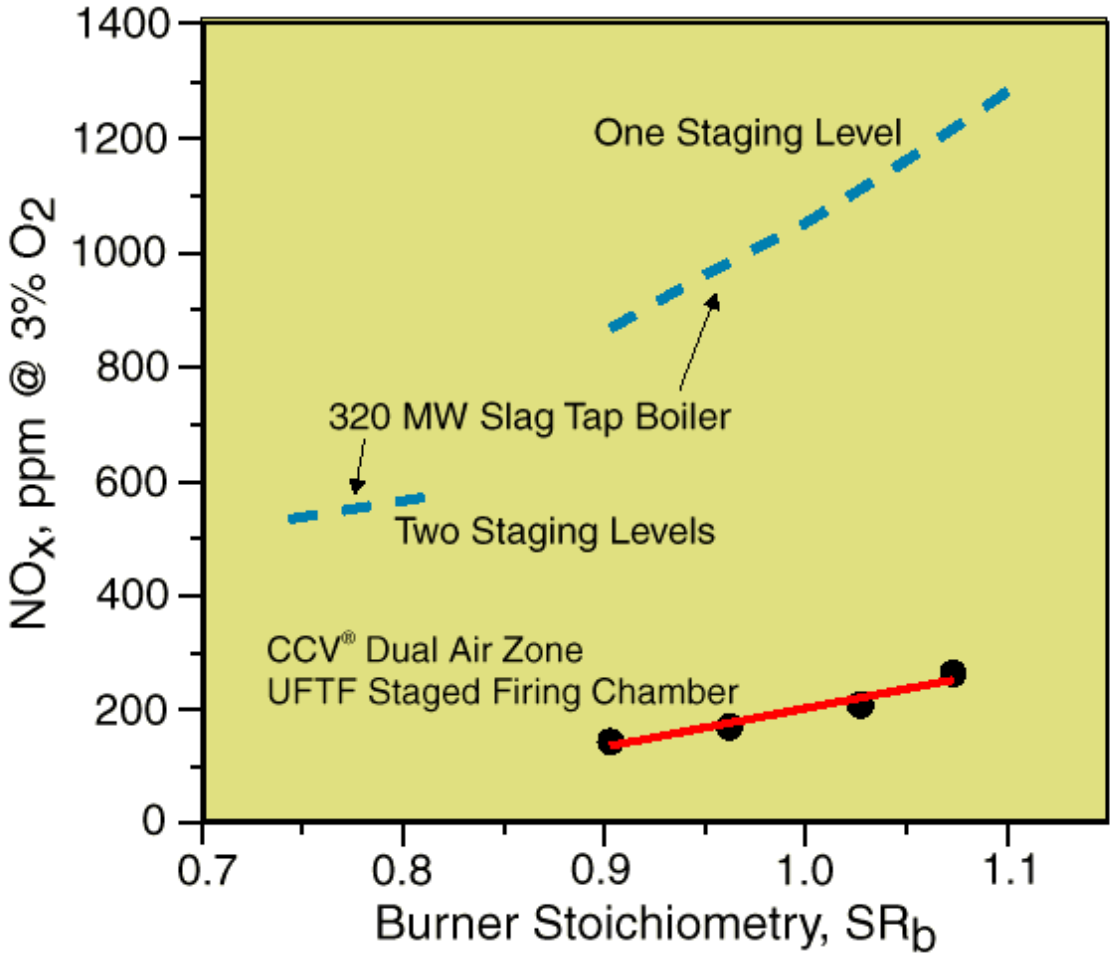


Burner Flames

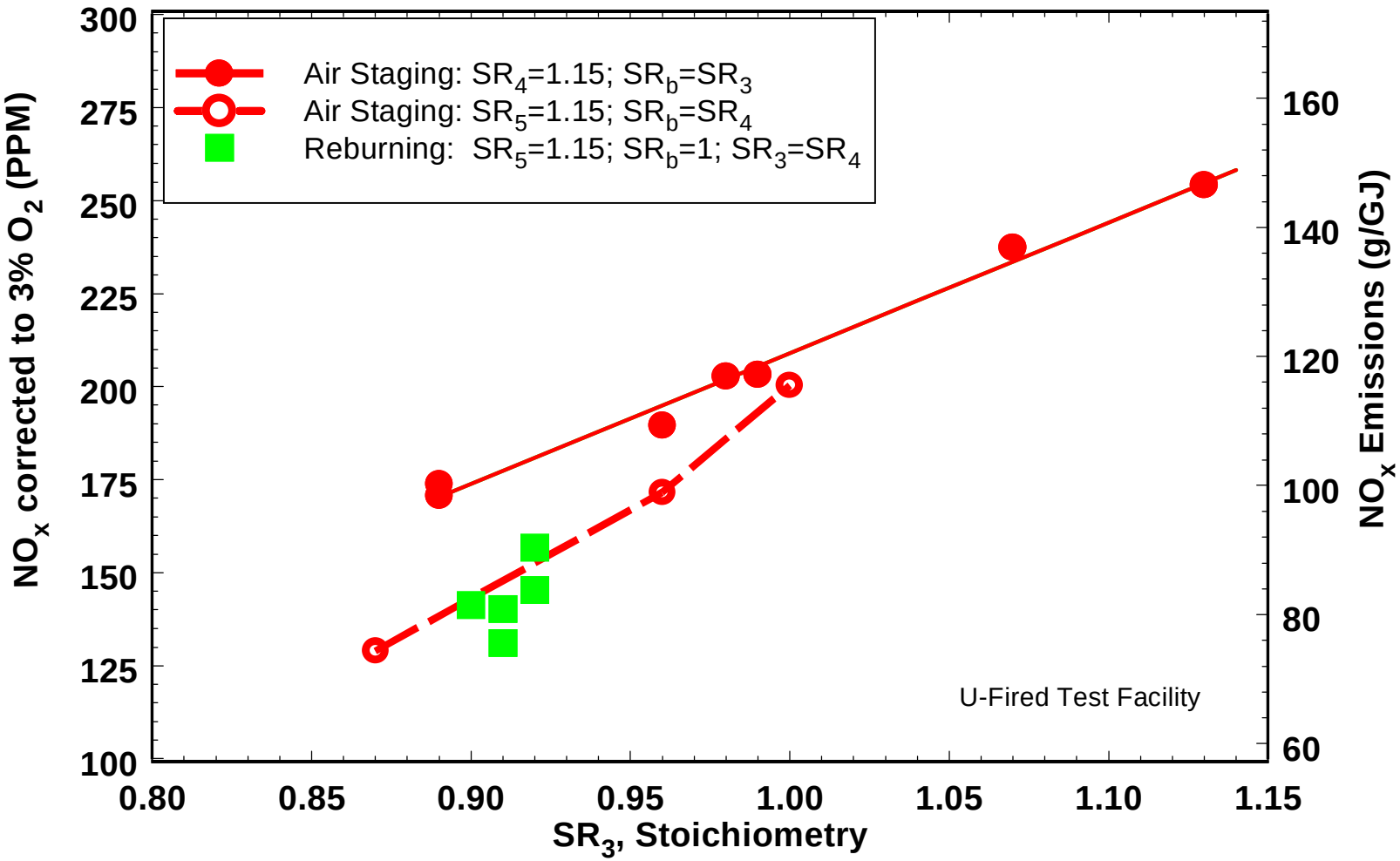
CCV Dual Air Zone

Baseline Burner

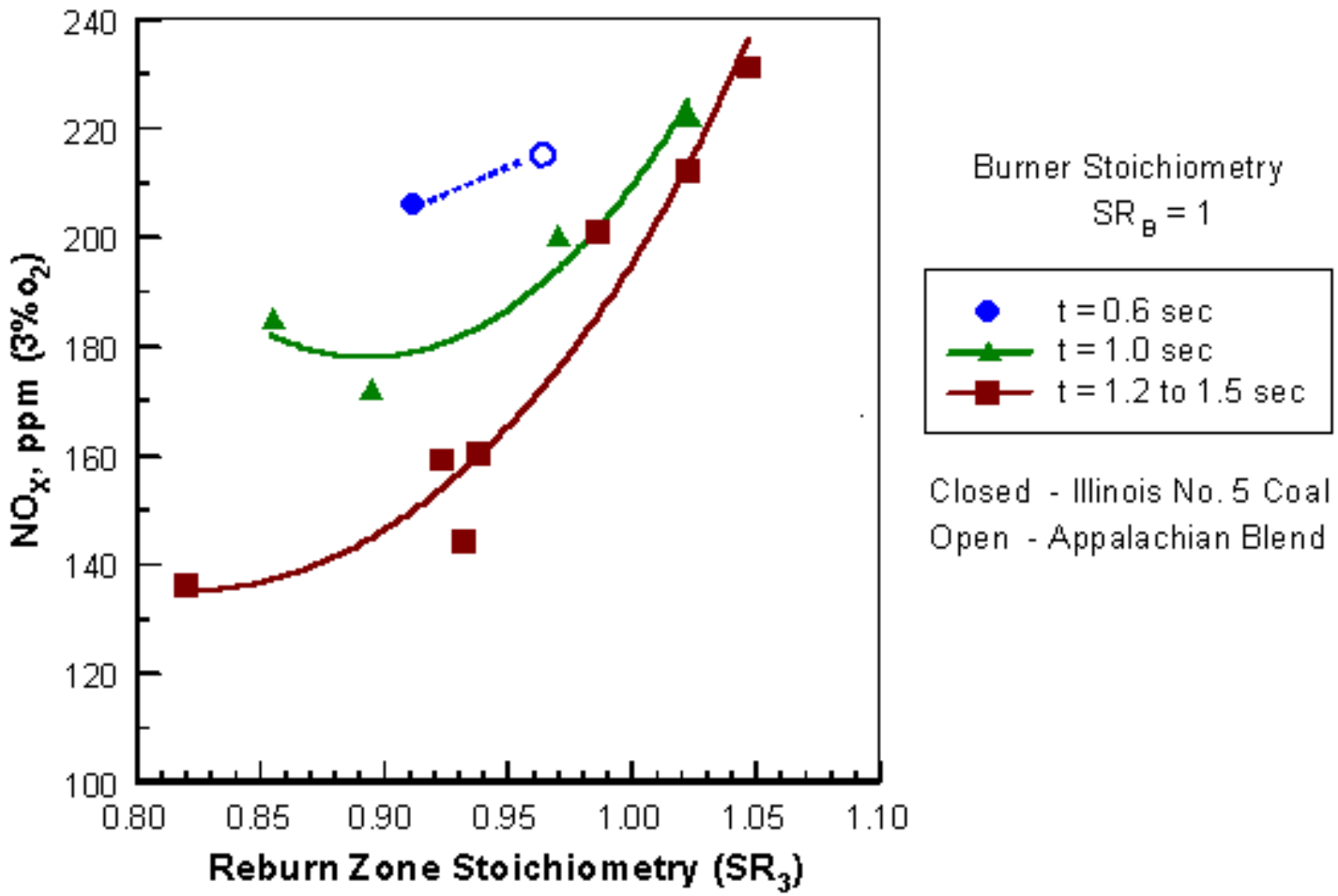
U-Fired NO_X Performance



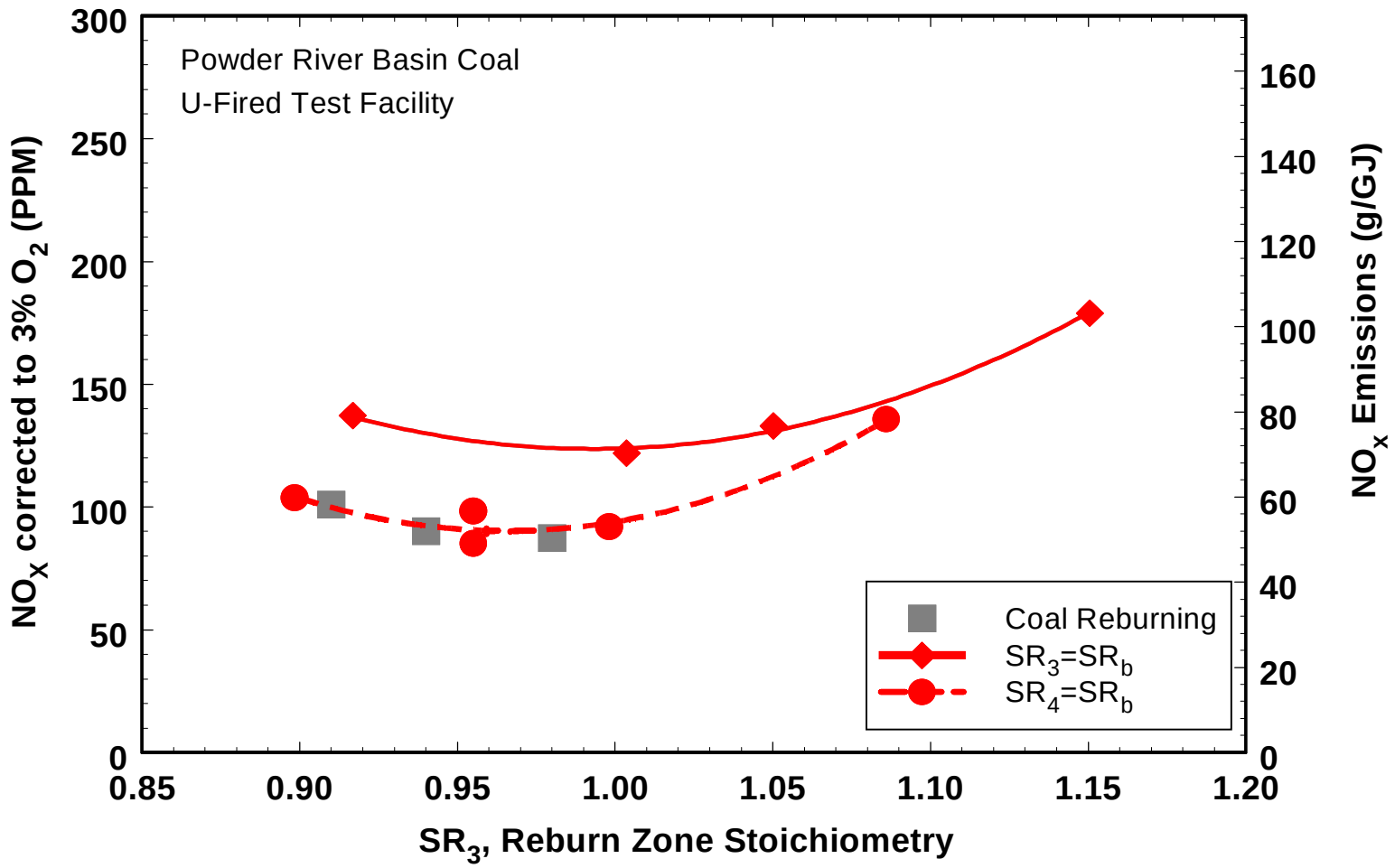
Air Staging/Reburning



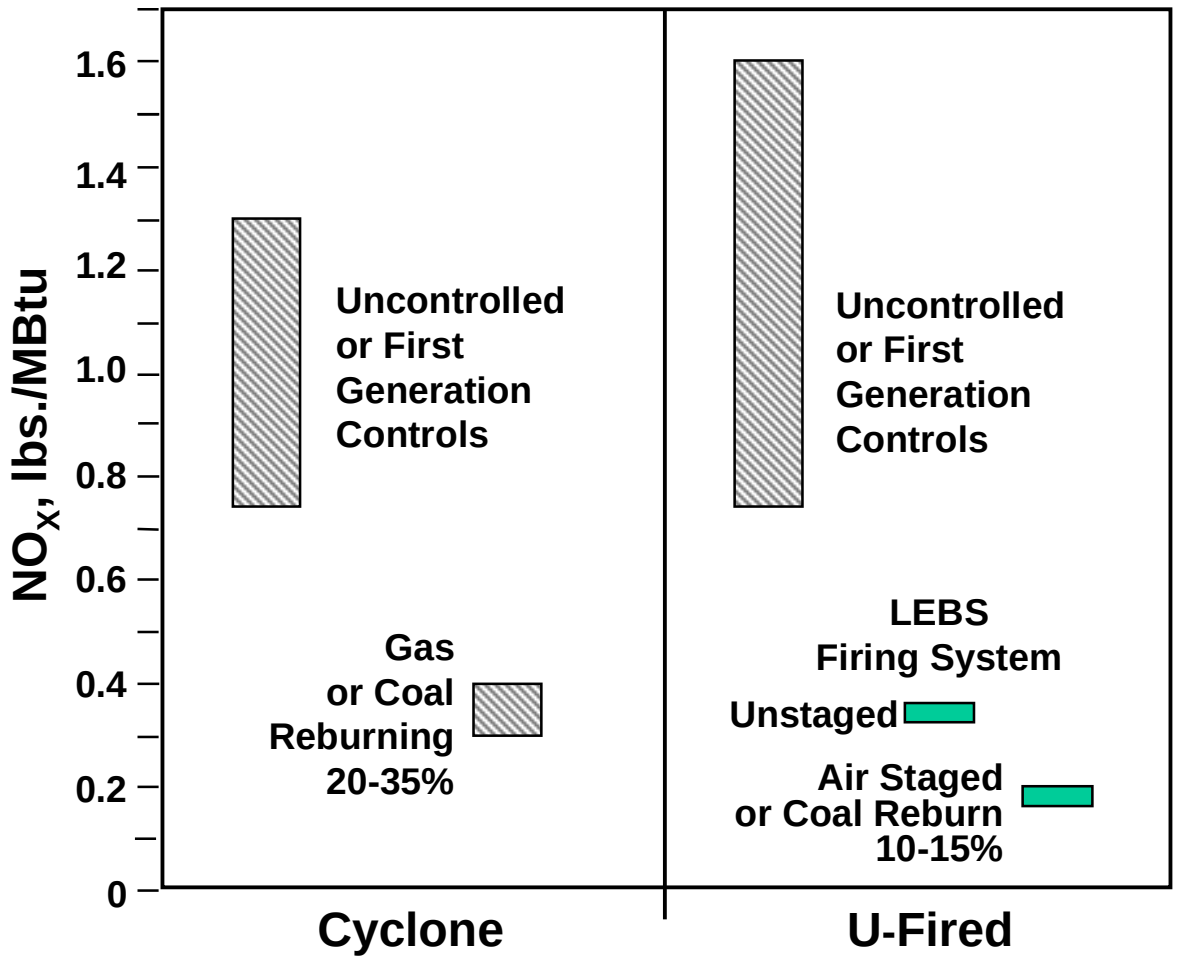
Effect of Reburn Zone Residence Time



Sub-bituminous Coal

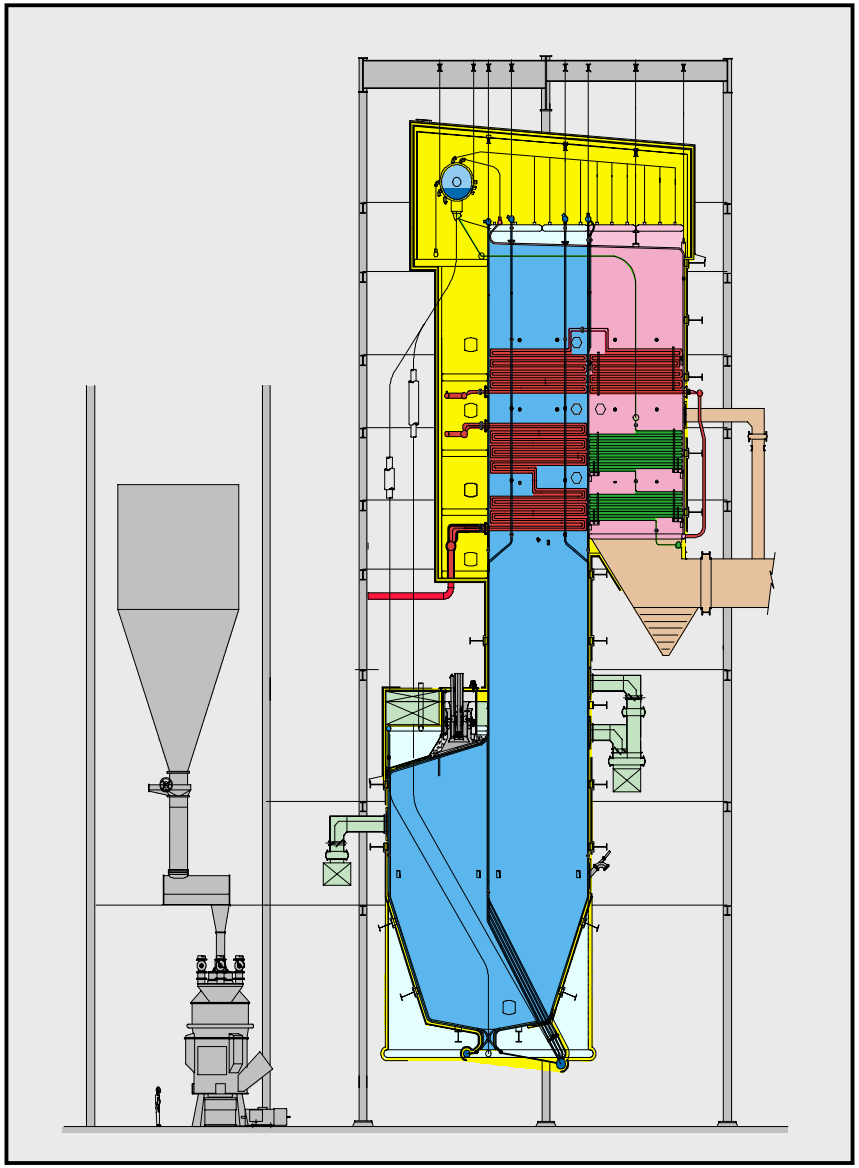


NO_X Emissions Slagging Combustion



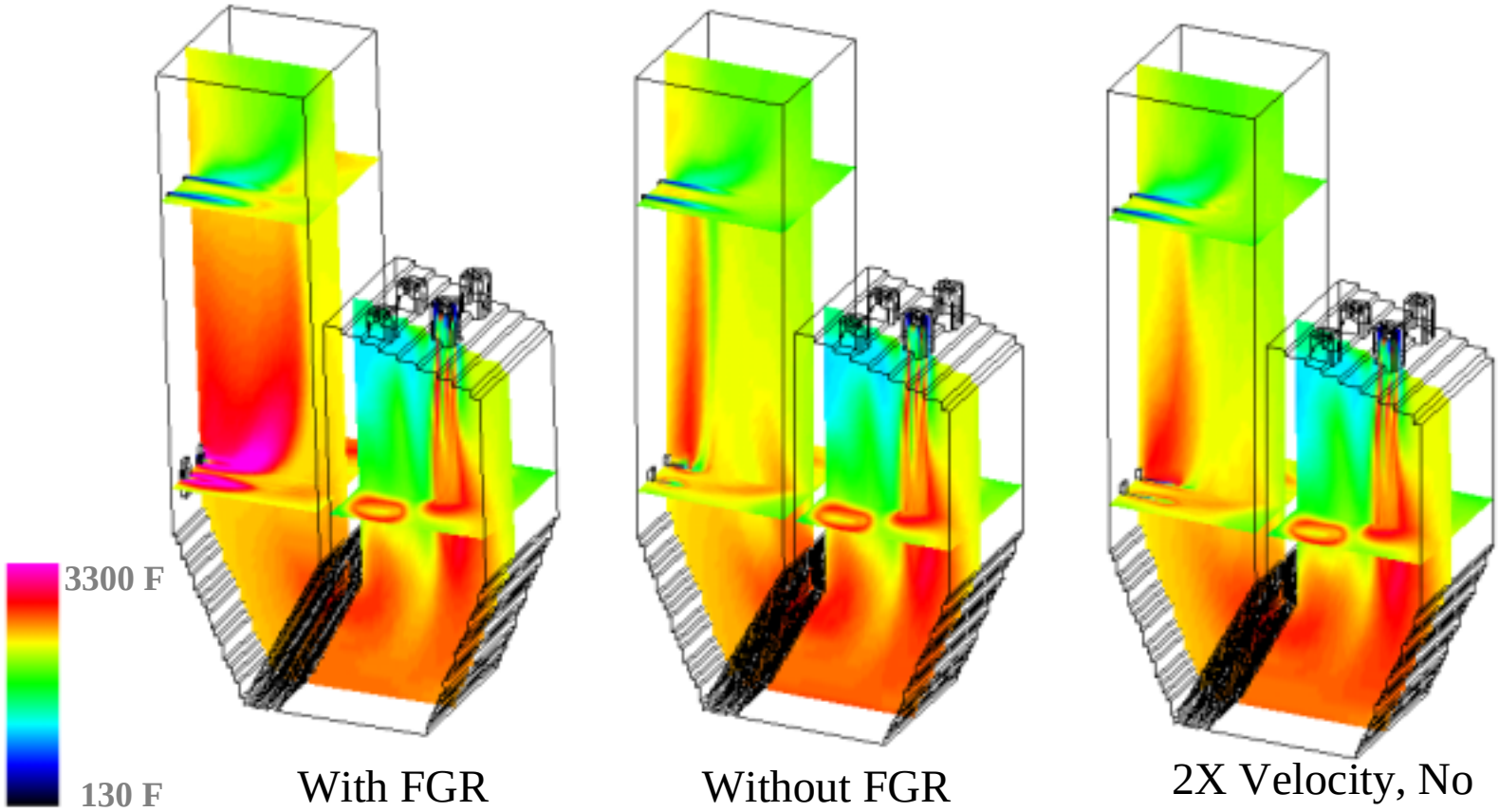
Proof-of-Concept Plant

- Nominal 80 MW, single firing chamber
- Base design for bituminous coal, 10% ash, 18% moisture
- Alternate design for waste coal, 25% ash, 25% moisture



Proof-of-Concept U-Fired Boiler

LEBS Firing System

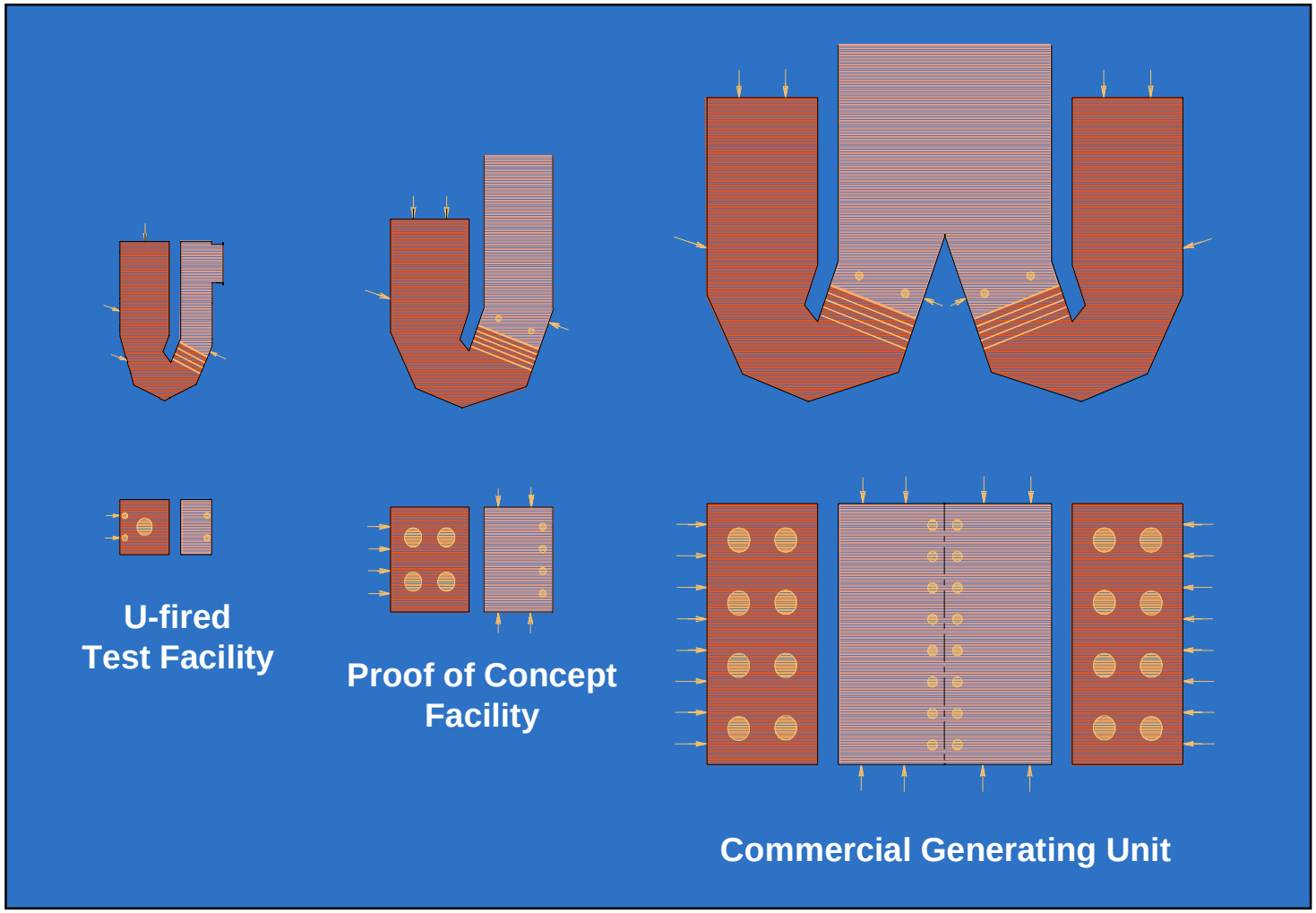


With FGR

Without FGR

2X Velocity, No FGR

Firing System Scale-up



Turris Mine, Elkhart, IL

LEBS POC 80 MW Facility

Conclusions

- Slag tap firing system based on design proven for ash management, firing of difficult fuels, reliable operation
- Boiler NO_X emissions controlled to levels achieved in low-NO_X dry bottom boilers
- Low carbon loss, CO under low excess air, low-NO_X conditions