MCILVAINE HOT TOPIC HOUR
SNCR - SCR

MARCH 26, 2015

I-NOx™ Integrated NOx Reduction Technology- *A Lower Capital Cost Solution for NO_x Reduction*

FUEL TECH
Technologies to enable clean efficient energy

Fuel Tech, Inc.
Stewart Bible

AGENDA

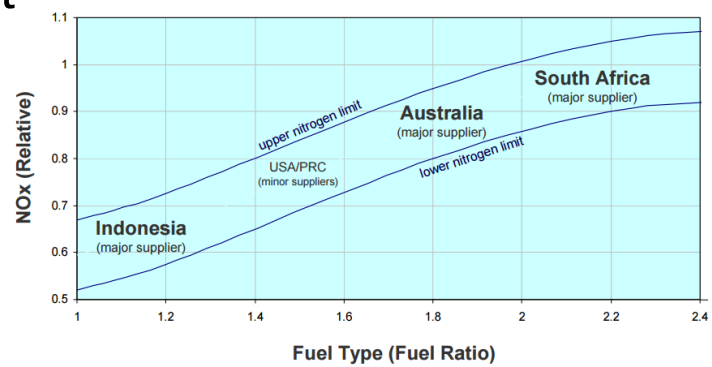
- Introduction
- I-NOx Technology & History
- Keys to Application
- Past Results
- Future Projects

FUEL TECH

- Fuel Tech seeks a cleaner, more energy efficient and sustainable environment.
- We provide innovative solutions in clean energy, including air pollution control systems such as:
  - Flue Gas Conditioning
  - Electrostatic Precipitator Improvements
  - I-NOx
    - » Low-NO_x Burners
    - » Over Fire Air Systems
    - » SNCR Systems
    - » SNCR Systems
    - » ULTRA Systems

I-NOX TECHNOLOGY

- The concept behind Fuel Tech's I-NOx technology has been around for many years.
- Various technologies have developed to meet ratcheting NOx regulations:
  - Choice of Coal



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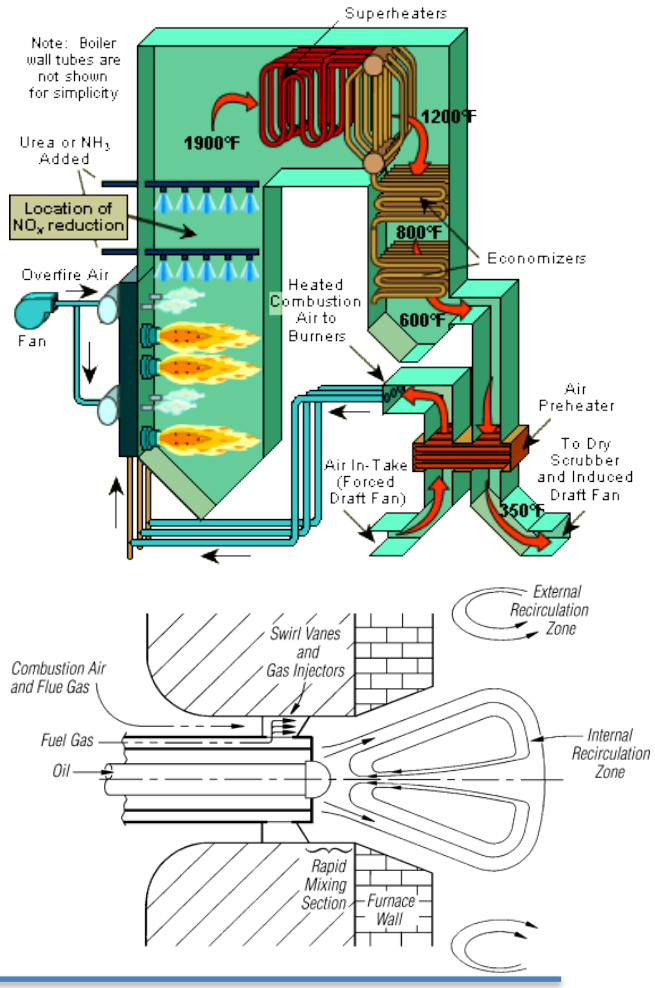
  - Combustion
    - » Staging Design
    - » Burner Design
      - Both were introduced in 1970s, both continue to develop today, represent the lowest capital cost per ton NOx mitigated



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    - » SNCR
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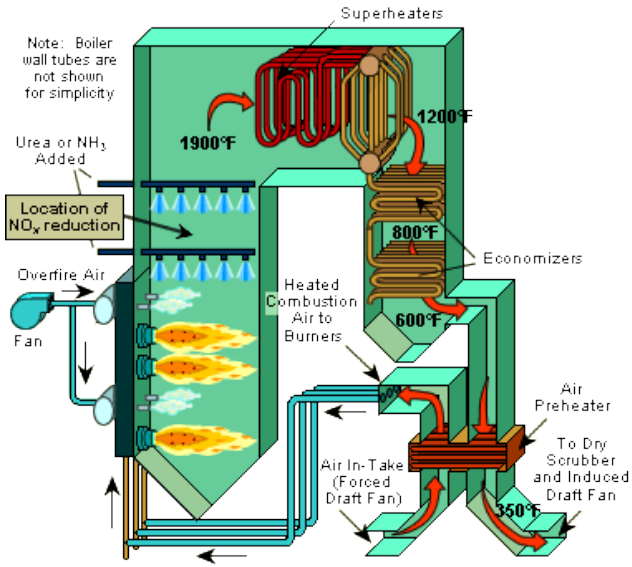

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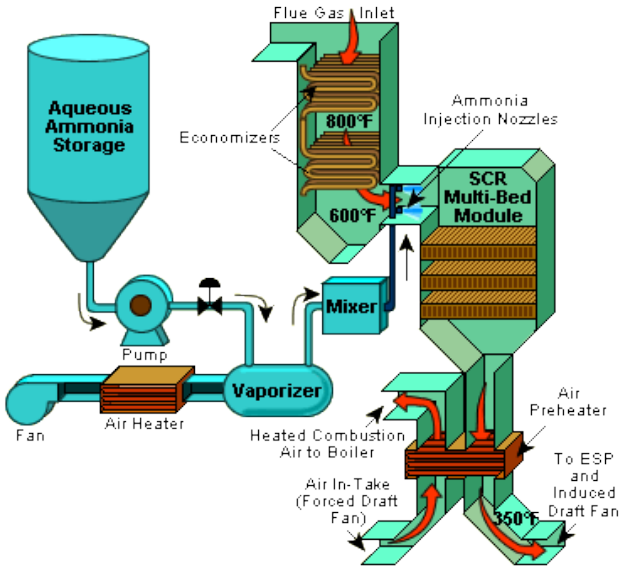
    - » SCR
      - Developed in 1990s, represents BACT NOx reduction but at highest capital cost



I-NOX TECHNOLOGY

- Combining these technologies was logical step in attempt to create low capital cost, high NOx removal system (1990s, patents by Fuel Tech) – *aka hybrid, in-duct, cascade, or advanced SCR*
- Early attempts:
  - Encina 2 (1992), gas/oil, 100 MW, Staged Comb. + SNCR + APH SCR (72% Total Post Comb.)
  - Mandalay 2 (1992), gas/oil, 107 MW, Staged Comb. + SNCR + APH SCR (82% Total Post Comb.)
  - Riedersbach 2 (1994), coal, 165 MW, Staged Comb. + SNCR + Boiler SCR (NH3 slip reduction) (80% Total Post. Comb.)
  - Mercer 2 (1996), coal, 321 MW, SNCR + In-Duct SCR + APH SCR (85% Total Post. Comb.)
  - Seward 15 (1999), coal, 147MW, SNCR + SCR, 60% Total Post Comb.)
  - Greenidge 4 (2005), coal, 147MW, SNCR + SCR, 60% Total Post Comb.)
  - And then…….

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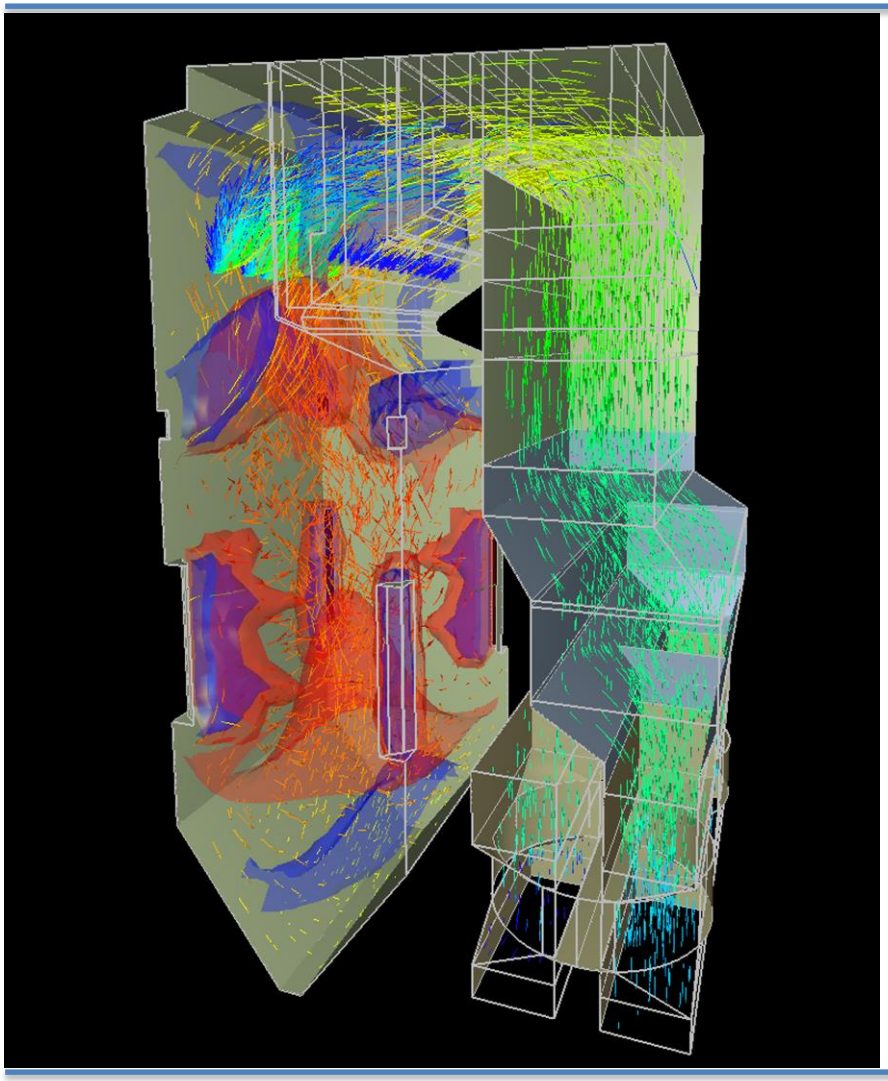
I-NOX TECHNOLOGY

- Combining technologies is not easy
- Design must be truly integrated:
  - SNCR design must account for combustion output and varying operational conditions of your typical boiler, easier if SNCR/SCR retrofit onto existing boiler where data can be measured
  - SCR design must account for SNCR output and varying operational conditions of the combustion and SNCR systems as boiler conditions fluctuate
- Challenges:
  - Highly maldistributed NOx and NH3 from boiler
  - Increased SCR velocity due to restrictions in catalyst installation space
    - » Both require expert knowledge in the design of all of the technologies being combined
    - » Both require computational and experimental fluid dynamics modeling coupled with flow distribution device optimization
- Benefits:
  - Capital cost, reagent consumption, dP, catalyst replacement, SO2-SO3 oxidation (lower minimum operating temperature)

I-NOX TECHNOLOGY



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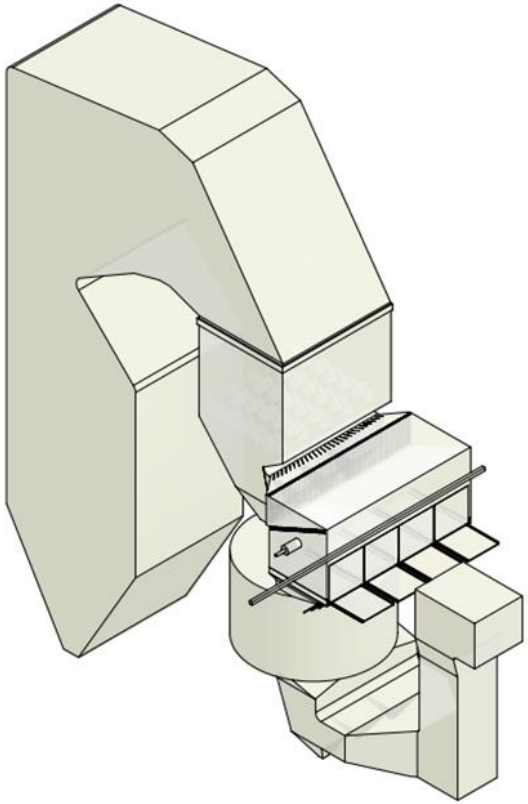
FUEL TECH CAPABILITIES

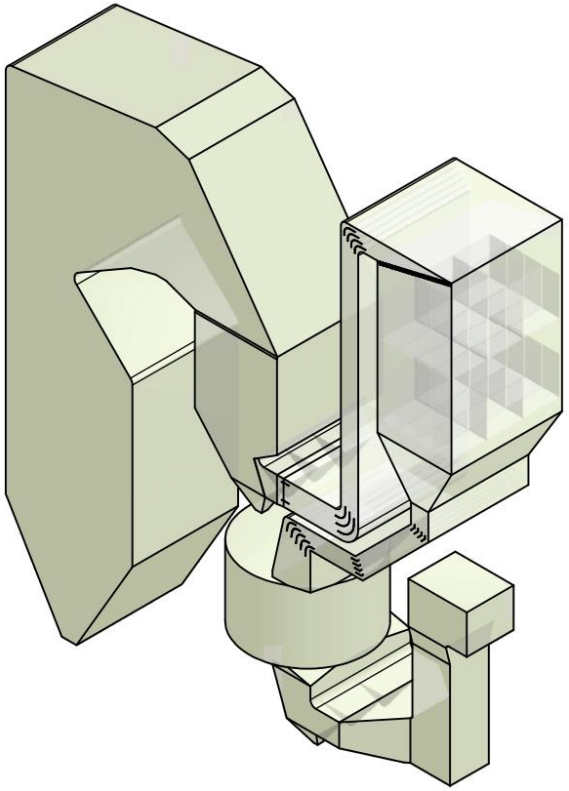
- 20 years of SNCR knowhow
- Acquisition of Advanced Combustion Technologies for combustion design
  - Low NOx Burners
  - Overfire air systems
- Acquisition of FlowTack/Tackticks for SCR
  - CFD/Experimental fluid dynamics
  - Flow distribution device optimization
  - Static mixer
  - Graduated Straightening Grid (GSG)
  - Reagent injection

CHINA STEEL CORPORATION, UNITS 6-8

- 3 X 50MW (coal)
- Units 6: 78% Reduction



- Unit 7 & 8: 87% Reduction



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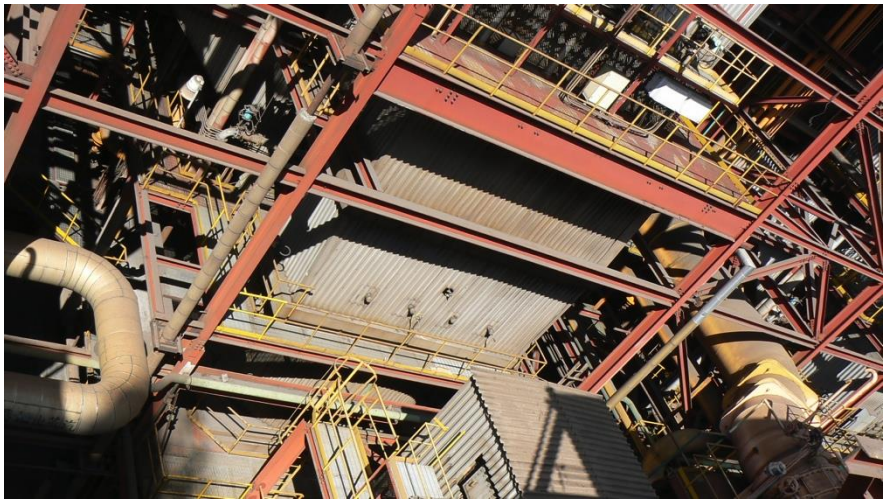
UNIT 7



Since the SCR required a minimal volume of catalyst, the necessary duct changes were greatly reduced. This allowed most of the existing duct work to be used in the new design and allowed for 1 week tie-in outage installation.

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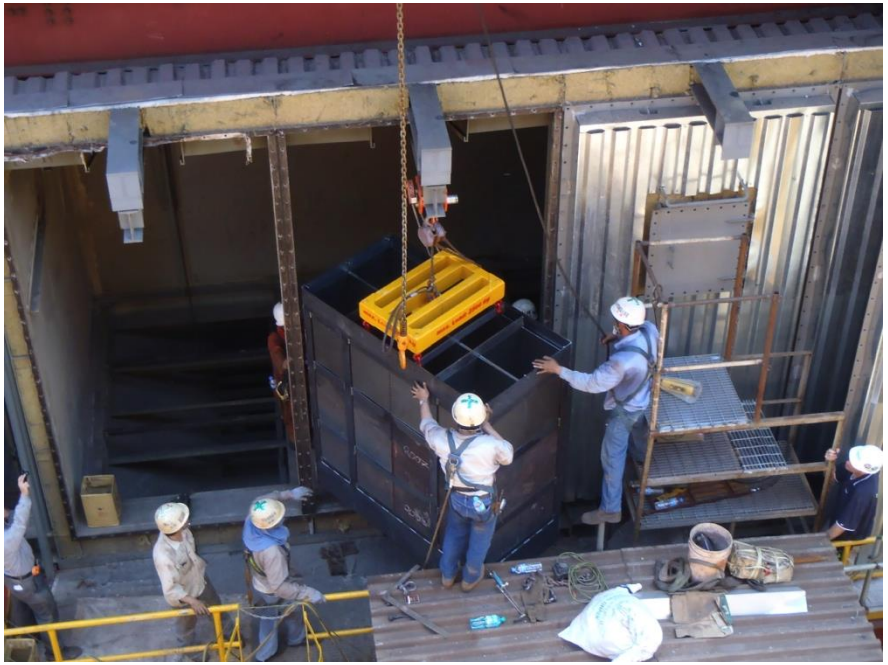
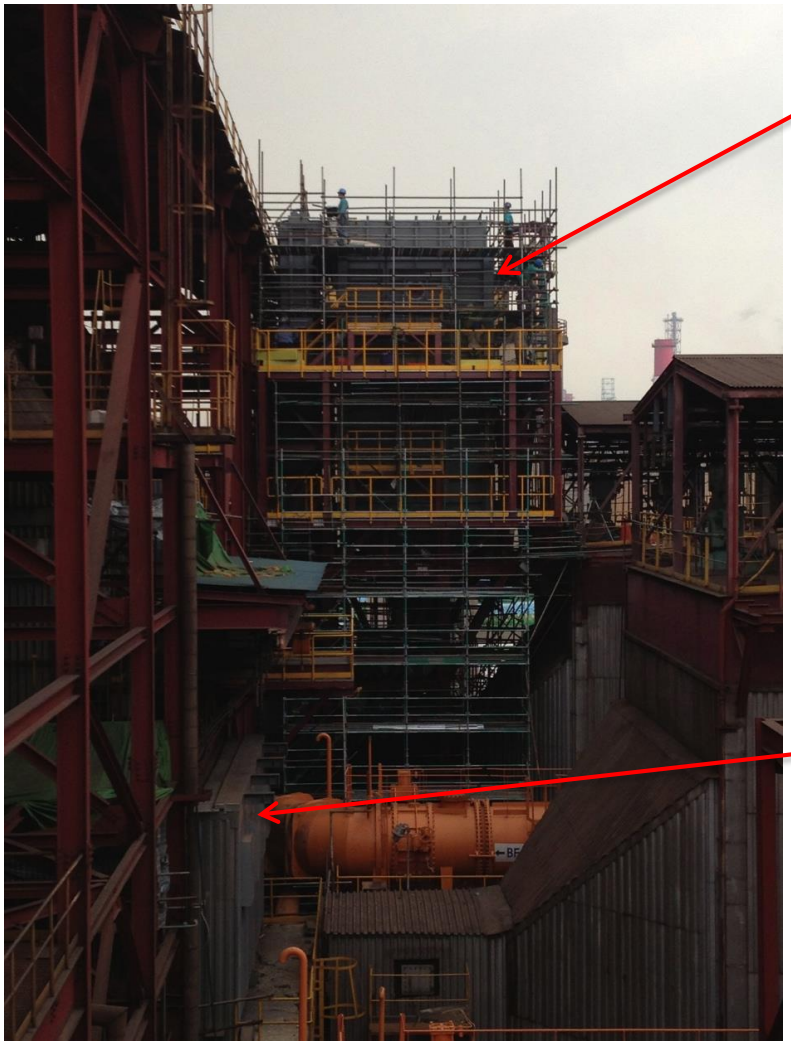
UNIT 7 CATALYST LOADING



Because the design minimized the necessary catalyst volume, the catalyst install could be completed in two working days.

Two of three sublayers originally installed, allowing for additional catalyst after the initial lifetime.

SIZE COMPARISON OF THE TWO PROJECTS



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CATALYST REQUIRED

- All three units met all performance guarantees:
  - 3 Fuel conditions (coal, COG, and BFG)
  - Multiple loads
  - Individual technology guarantees (LOI, NOx, NH3 slip, dP)
- The customer noted that they appreciated most the flexibility the system offered in operation.
  - Boiler operation fluctuates with heavy rains of Taiwan and wet coal, requires furnace adjustments to maintain load and can significantly impact NOx/CO/O2 profiles leaving the boiler. The combined SNCR/SCR operation can be adjusted to accommodate these changes without impacting NOx at stack.
  - “SCR Lead” reagent injection control provides automatic best use of reagent, when load is low, SNCR is not required.

Thank You

Questions?

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