Adaptation of existing SNCR system to meet BREF limits of 150 mg and beyond

Presented by: Hanif Suchwani
MEC 13 AGENDA

• Fuel Tech Introduction

• Selective Non-Catalytic Reduction (SNCR)
  o Design considerations
  o Application of Multi Nozzle Lance (MNL)
  o Case Study (Utility sized 550 MWe and 650 MWe)

• Advanced SCR (ASCR)
  o Design considerations
  o Case Study (200 TPH Boiler with Staged NOx Control)

• Questions
FTI is an industry leading producer of state-of-the-art air pollution control and combustion process optimization technology for power generation boilers

- **A pioneer** in the development of Nitrogen Oxide (NOx) emissions reduction using SNCR technology
- **Over 30 years** experience serving as a trusted partner helping international governments and power producers achieve their emission reduction objectives
- Solutions used in **over 900** utility and industrial boilers in **26 countries**
- In-house laboratories and a focus on research & development ensure access to **leading edge technologies and solutions**

- Founded in 1981
- Listed on NASDAQ since 1993 (“FTEK”)

FTI has a clear corporate vision to create “a cleaner, more energy-efficient, sustainable environment to benefit the world’s present and future generations”
# SELECT FTEK EXPERIENCE

<table>
<thead>
<tr>
<th>Technology</th>
<th>Total Deployments / MW</th>
<th>Deployments by Geography</th>
<th>Deployments by End Market</th>
<th>FTI Advantage</th>
</tr>
</thead>
</table>
| SNCR                        | 700+ / 51,300          | ![SNCR Deployments](image) | ![SNCR End Market](image) | • Sophisticated modular and unique process design  
• Unparalleled system installation experience and know-how  
• Proprietary modeling enables industry leading system efficiency and design |
| TIFI®                       | 110+ / 21,900          | ![TIFI Deployments](image) | ![TIFI End Market](image) | • Unique construction and modeling, injection system design, equipment and chemical solutions  
• Skilled system design experience across all operating conditions  
• Ability to lower operating costs without sacrificing performance |
| ULTRA®                      | 110+ / 27,700          | ![ULTRA Deployments](image) | ![ULTRA End Market](image) | • FTI invented the technology and therefore has the most scientific basis, design expertise and experience  
• Recently began deploying the fifth generation of the technology  
• Enhanced safety |
| Combustion Modifications    | 110+ / 16,400          | ![Combustion Deployments](image) | ![Combustion End Market](image) | • Unique Insight – The combination of unparalleled experience (>110 system installations) and unique in-house modeling systems create highly differentiated capabilities  
• Balanced Combustion Performance – Focus on complete system optimization, not just NO\textsubscript{x} reduction |
| SCR, ASCR and Catalyst Management Services | 150+ / 63,200 | ![SCR ASCR Catalyst Management Deployments](image) | ![SCR ASCR Catalyst Management End Market](image) | • Over 20 years of SCR design experience  
• Extensive modeling experience to design and or fix underperforming systems  
• Unique ability to layer smaller SCR systems with other NO\textsubscript{x} control technologies to achieve similar results to full size SCRs |

![FTEK Experience Chart](image)
BREF and the control of Nitrogen Oxides
Prior to BREF publication, operators have been either switching fuels or installing primary and secondary methods to achieve < 200 mg/Nm3 NOx.

BREF now requires 150 mg/Nm3 and there is a possibility of lower emissions limits of 100 mg/Nm3 in the future.

Some of the current options are:

1. Full SCR system
2. Adapting existing SNCR to meet initial 150 mg/Nm3 requirements and then upgrade with a compact catalyst to meet 100 mg/Nm3
LIMITATIONS OF FIRST GENERATION SNCR

SNCR Systems have been developed for more than 30 years;
- cement kilns/waste incinerators > 75% NOx reduction
- coal fired utility boilers are limited typically to sub 40% reduction.

Performance limiting factors for SNCR in utility boilers:
- Temperature window
  - High CO requires a lower injection temperature
  - Lower temperatures = higher NH3 slip
- Physical dimensions
  - Traditional injectors unable to reach temperature window
    - Risk of tube failure
- Sulphur in the fuel
  - Higher S content in fuel results in SO3 formation
    - SO3 and NH3 slip result in ABS formation plugging airheaters
This example shows the relationship between temperature and CO for a particular boiler:

As CO levels at the point of chemical release increase, the ideal temperature changes from 960°C to 860°C.
TEMPERATURE WINDOW

CFD images compare reagent distribution using Multi Nozzle injectors (MNL)

Conventional wall mounted system shows less than 50 % of the flue gas can be reached using injection on the front wall alone.

The addition of MNL injectors above the furnace arch allow almost complete coverage of the flue gas – better coverage = lower overall NOx for the equivalent reagent consumption.
MULTI-NOZZLE LANCE

- Water-cooled retractable lance for Urea injection
- Provides excellent chemical coverage
  - Improves Chemical utilization
  - Decreases water consumption compared to wall injection
- Use of the water cooled MNL began in 1990
- Can provide more than 8 meters of insertion depth
- Fine spray pattern appropriate for super-heat section
- Large spray pattern can be used in upper furnace
- Numerous applications in use for more than 10 years
  - Robust design and safety considerations
  - Coal ash levels as high as 27.5%
  - On-line cleaning through periodic retraction
WATER-COOLED MULTI-NOZZLE LANCE
CLECO POWER LLC – DOLET HILLS 1

• 1986 Vintage B&W
• 650 MWn B&W, Lignite-fired
• Balanced Draft, Subcritical Boiler
• B&W Burners
• ESP with Wet FGD
• 2012 SNCR Retrofit Driven by CSAPR
• BOP Engineer – S&L
• Installation Contractor - PMSI
• System Installed and Currently Idle Pending Regulatory Driver
• 1982 Vintage Foster Wheeler
• 523 MWn, PRB-fired
• Balanced Draft, Subcritical Boiler
• ABT Burners
• ESP with Wet FGD
• 2012 SNCR Retrofit Driven by CSAPR
• BOP Engineer – S&L
• Installation Contractor – PMSI
• System Installed and Currently Idle Pending Regulatory Driver
# CLECO SNCR PERFORMANCE

<table>
<thead>
<tr>
<th>Design Parameter</th>
<th>Dolet Hills 1</th>
<th>Rodemacher 2</th>
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<tbody>
<tr>
<td>Boiler OEM</td>
<td>B&amp;W</td>
<td>Foster Wheeler</td>
</tr>
<tr>
<td>Coal Fired</td>
<td>Lignite</td>
<td>PRB</td>
</tr>
<tr>
<td>Gross Load (MW)</td>
<td>700</td>
<td>530</td>
</tr>
<tr>
<td></td>
<td>495</td>
<td>250</td>
</tr>
<tr>
<td>Gross Heat Input (GJ/hr)</td>
<td>7180</td>
<td>5665–5772</td>
</tr>
<tr>
<td></td>
<td>5384</td>
<td>2854</td>
</tr>
<tr>
<td>Baseline NOx Emissions (mg/Nm3)</td>
<td>302</td>
<td>308</td>
</tr>
<tr>
<td></td>
<td>226</td>
<td>220</td>
</tr>
<tr>
<td>NOx Reduction (%)</td>
<td>27.5</td>
<td>20–25</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Controlled NOx Emissions (mg/Nm3)</td>
<td>220</td>
<td>228 – 247</td>
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<tr>
<td></td>
<td>193</td>
<td>197</td>
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<tr>
<td>CO Baseline Concentration (ppm, avg)</td>
<td>995</td>
<td>400</td>
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<tr>
<td></td>
<td>50</td>
<td>100</td>
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<tr>
<td>Flue Gas O2 at Boiler Exit (%)</td>
<td>2.3</td>
<td>3.1–3.3</td>
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<tr>
<td></td>
<td>4.6</td>
<td>3.4</td>
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<tr>
<td>Furnace Exit Gas Temperature (°C)</td>
<td>1054</td>
<td>1157</td>
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<tr>
<td></td>
<td>910</td>
<td>926</td>
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</table>
NRG – BIG CAJUN II – UNIT 1

- 1976 Vintage Riley Turbo
- 650 MWg, PRB-fired
- ESP with Wet FGD
- 2014 SNCR Retrofit Driven by Consent Decree
- BOP Engineer – S&L
- System Installed and Currently Operating at or Below its Consent Decree Limit
## NRG SNCR PERFORMANCE

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<th>Design Parameter</th>
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<tr>
<td>Boiler OEM</td>
<td>Riley Turbo</td>
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<tr>
<td>Coal Fired</td>
<td>PRB</td>
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<td>Gross Load (MW)</td>
<td>602</td>
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<tr>
<td></td>
<td>580</td>
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<tr>
<td>Gross Heat Input (GJ/hr)</td>
<td>6270</td>
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<td>6040</td>
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<td>Baseline NOx Emissions (mg/Nm3)</td>
<td>270</td>
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<tr>
<td></td>
<td>258</td>
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<tr>
<td>NOx Reduction (%)</td>
<td>28</td>
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<tr>
<td>Controlled NOx Emissions (mg/Nm3)</td>
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<td>CO Baseline Concentration (ppm, avg)</td>
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<td>1000+</td>
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<tr>
<td>Flue Gas O2 at Boiler Exit (%)</td>
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<tr>
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<tr>
<td>Furnace Exit Gas Temperature (°C)</td>
<td>1210</td>
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<td>1100</td>
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</tbody>
</table>
ASCR DESIGN PRINCIPLES

- Selective Catalytic Reduction (SCR) is the Best Available Control Technology for NO\textsubscript{x} reduction but, is limited in application due to high capital cost requirements.
- On retrofit applications there are often further difficulties associated with space and existing plant equipment capacity.

- The ASCR approach can achieve similar overall NO\textsubscript{x} reduction as a SCR but with a greatly reduced capital cost.
- An ASCR combines multiple lower capital cost technologies including Low-NO\textsubscript{x} burners, OFA, and/or SNCR in combination with a compact SCR reactor.
- The ASCR reactor requires less catalyst, a smaller footprint and less duct modifications - all resulting in a greatly reduced capital cost when compared with a traditional “full SCR”.

Lower NO\textsubscript{x} Baseline via Combustion and SNCR Improvements

Less Catalyst

Minimal Duct Modifications

Substantially Less Capital Cost
LOW NOx: DESIGN CHALLENGES

Combustion
- Strongly influenced by fuel characteristics.
- Different coals can require different settings.
- Mistuned and poor combustion settings would produce greater NOx and CO.
- Online advanced measurement systems for gas species and temperature control can be used to adjust OFA amounts and distribution.

SNCR
- High CO will decrease SNCR performance (results in less NOx removal and greater NH3 slip). This happens at local zones with high CO and/or if the boiler has high overall CO levels.
- Care must be taken to achieve the maximum reagent distribution.
- Higher baselines provide a higher degree of reduction possibilities.

SCR
- NOx/NH3 maldistributions after the SNCR greatly affect SCR performance. Regions with elevated NOx or NH3 concentrations would reduce SCR performance.
- Mixing of the flue gas is required to even out an uneven distribution from the SNCR system.
- Final SNCR NOx affects the final SCR NOx.
• 470 mg/Nm3 NOx baseline requiring 78% reduction to under 100 mg/Nm3 @ 6% O2.

• Existing measures were changed/upgraded as appropriate.
  • LNB replaced with Fuel Tech LNB,
  • Existing Fuel Tech SNCR was upgraded
  • New Over-Fire Air (OFA) System.
  • Small SCR reactor between the economiser and air heater.
    • Single layer reactor with 12 modules of plate catalyst.

• ASCR system cost was 50% of the full SCR option. All performance guarantees met, an additional 2 units were contracted.
The single layer of catalyst for the SCR portion meant only a slight expansion of the duct was necessary reducing costly duct modifications and pressure drop across the entire system.
FUEL TECH EXPERIENCE AND BENEFITS

- Extensive Commercial Experience
  - Over 100 LNB/OFA Systems from 20 MW to 1200 MW
  - Over 700 NOxOUT and HERT Systems Worldwide, More Than 100 Utility Applications
  - Over 55,000 MW of SCR Design, 20,000 MW AIG Tuning Experience Worldwide
  - NOxOUT ULTRA® Systems, Over 180 Units to Date, 2.5 to 550 kg/h of SCR Reagent Feed Systems

- Fuels and Boiler Types
  - Coal, Biomass (Wood, MSW, Bagasse, Etc.), Gas, Oil, Tires, Etc.
  - T-Fired, Stoker, Wall Fired, Down Fired, Incinerators, Etc.

- Quality Equipment with Low Maintenance Cost
  - Stainless Steel Design for Long Life and Durability

- Guaranteed Performance
  - NOx Reduction, NH3 Slip, Reagent Consumption, CO, LOI
Thank you