REINHOLD ENVIRONMENTAL Ltd.

2011 NOx-Combustion Round Table & Expo Presentation

February 7-8, 2011, in Birmingham, AL / Hosted by Southern Company

SNCR Operation Workshop

February 7, 2011

NO_x Roundtable Conference

Birmingham, AL

Kevin Dougherty - Fuel Tech

Fuel Tech Overview

- **FUEL CHEM® Technology**
  - Boiler Efficiency and Availability Improvements
  - Slag and Corrosion Reduction
  - Controls SO_3 Emissions and Addresses Related Issues
- **Innovative Approaches to Enable Clean Efficient Energy**
  - Capital Projects for Multi-Pollutant Control
  - NO_XOUT® Products including SNCR, CASCADE, RRI, ULTRA
  - Flue Gas Conditioning Systems for Particulate Control – Outside US and Canada
  - Sorbent Injection for SO_2 Control
- **Flow Modeling and SCR Catalyst Management Services**
  - Computational Flow Dynamics and Physical Flow Modeling for Power Plant Systems
  - SCR System Optimization and Catalyst Management Services
- **Technology solutions based on Advanced Engineering Computer Visualization and Modeling**
- **Strong Balance Sheet (Stock Symbol: NASDAQ – FTEK)**

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Recent Developments

- **Full Spectrum of Multi-Pollutant Control Options to Minimize Capital Investment and Maximize Performance**
- **Mercury**
  - **TIFI through SO_3 Mitigation Improves Hg Capture**
  - **NO_xOUT Cascade provides 90+% Hg Oxidation with a single layer of SCR Catalyst**
- **Particulate**
  - **Flue Gas Conditioning Injection Systems for ESP Performance Enhancements**
  - **Markets Outside the US and Canada where Coal Ash is more difficult for ESP collection**
  - **Sonic Horns for Economizer and Backend Issues**
- **SO_2 - Sorbent Injection Systems Low Capital Option (30-40% Reduction)**
- **SO_3 - TIFI controls backend issues**
- **Large Particle Ash - TIFI reduces Popcorn Ash Cleaning**

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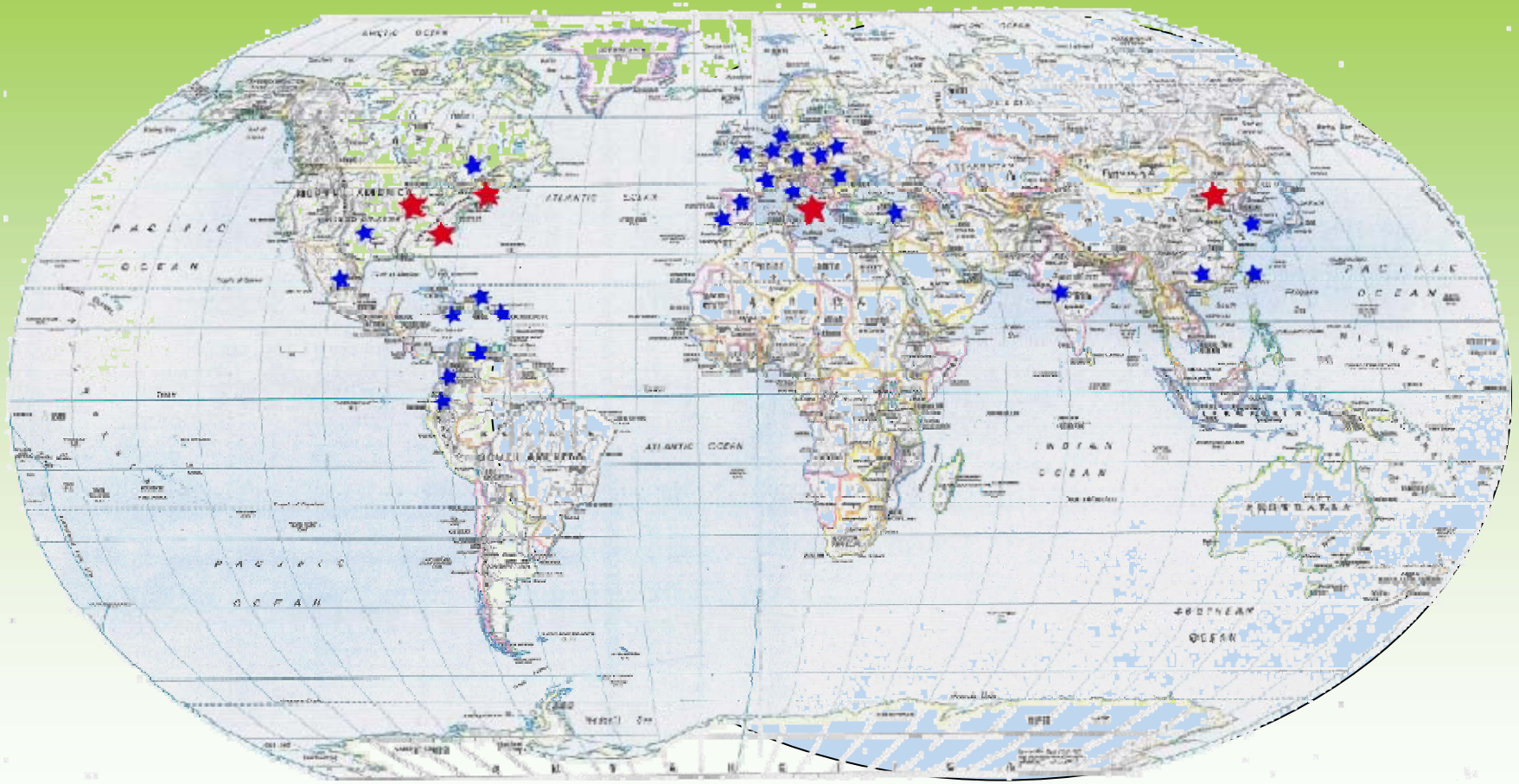
Fuel Tech's Global Presence



★ **Office Locations:** Warrenville, IL; Stamford, CT; Durham, NC; Milan, Italy; Beijing, China

★ **Countries where Fuel Tech does business:** USA, Belgium, Canada, China, Columbia, Czech Republic, Denmark, Dominican Republic, Ecuador, France, Germany, India, Italy, Jamaica, Mexico, Poland, Portugal, Puerto Rico, Romania, South Korea, Spain, Taiwan, Turkey, United Kingdom, Venezuela

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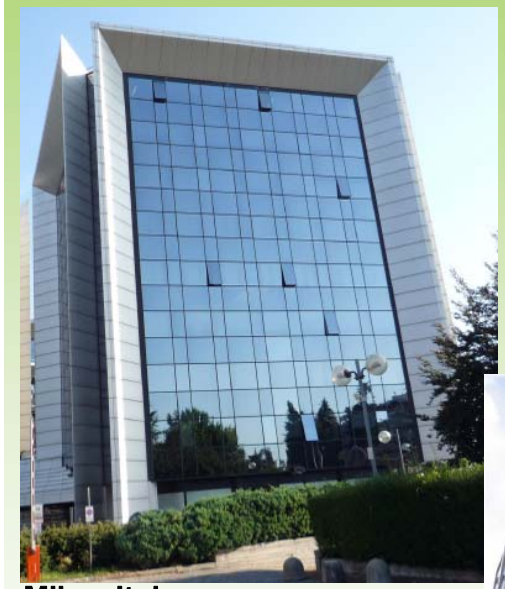
Our Locations

Stamford, CT

Durham, NC



Milan, Italy

Warrenville, IL

Beijing, China

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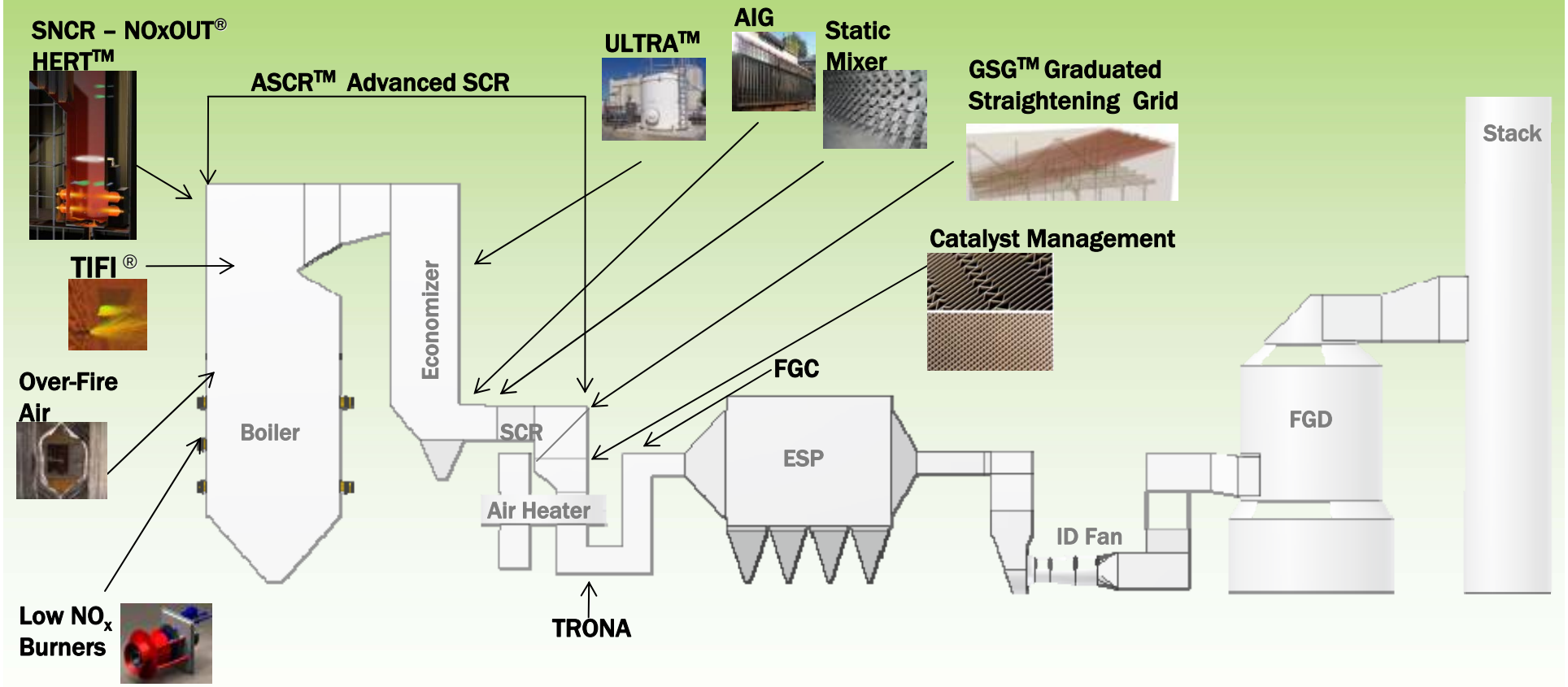
Typical Power Plant



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FUEL CHEM®

- **Multiple Solutions**
- **Operating Program**
- **Overview**

FUEL CHEM® Program

- **Slag – the iron, sodium and other minerals in coal that do not burn**
- **Above the ash fusion temperature these minerals melt and adhere to steam pipes and boiler walls**
- **More economical coals can have higher slagging properties**
- **Traditional removal methods**
  - During Operations:
    - Air / water cannons
    - Thermal shocking
  - Shotguns
  - During Outages (6-10 days):
    - Dynamite
    - Mechanical Removal with Scrapers / Chisels / Etc.

Example of a clinker fall

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FUEL CHEM® Program Benefits

- **Efficiency**
  - Recovery of Derated MW
  - Heat Rate Improvement for Steam Production
  - Reduced Fan Power Requirements
  - Reduced Sootblowing
  - Reduced Operating O_2 Level
  - Reduced CO in Furnace and at the Stack
  - Increased Fuel Flexibility

- **Availability and Reliability**
  - Reduced Forced Outage Time
  - Reduced Derates
  - Increased Capacity and Boiler Availability
  - Reduced Outage Cleaning Times
  - Reduced Exit Gas Temperatures

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FUEL CHEM® Program Benefits

- **Environmental**
  - CO_2 Reduction
  - SO_3 Reduction
  - Opacity Improvement
  - Promotes Mercury Capture
  - Reduced Large Particle Ash (LPA)
- **Safety**
  - Reduced Maintenance Operations
- **Maintenance**
  - Reduced Corrosion in Economizer, Air Heater, Ductwork, and Stack
  - Reduced Clinker Grinder Maintenance
  - Tube Life Extension
    - Reduced Sootblowing
    - Reduced Slag Damage
  - Reduced Cleaning Expenses
    - Less Explosives
    - Lower Water Consumption

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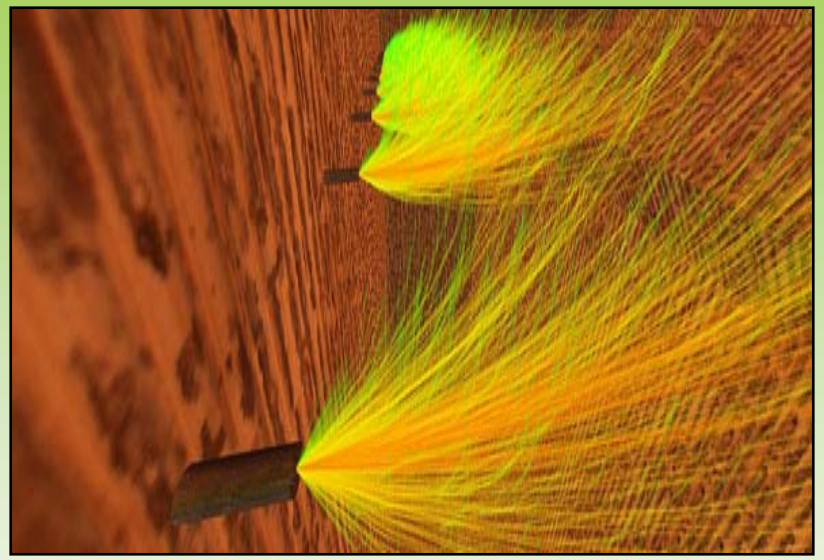
TIFI® Targeted In-Furnace Injection™ Program

TIFI® Targeted In-Furnace Injection™ Technology

- Improves Fuel Flexibility
- Reduces Slagging and Fouling
  - Providing Greater Boiler Efficiency
- SO_3 Plume & Opacity Control
- Heat Rate Improvement



TIFI® Injector on boiler wall

Fuel Types

Coal	Alternative Fuels	Residual Fuels
• PRB • ILB • Lignite • CAPP	• Biomass • Pet Coke • Hog Fuels • WTE Fuels	• No. 6 Fuel • Waste Oil • Bunker C • Liquid Waste Fuels • Black Liquor

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TIFI ® Technology Overview

TIFI MG™

- Utilizes magnesium hydroxide slurry
- Sprayed into the combustion unit at locations defined by computer modeling.
- TIFI MG solution reacts with slag as it is forming and penetrate existing deposits.

TIFI XP™

- Builds upon TIFI technology
- Designed to provide users both slag control and fuel flexibility.
- Allows users to burn less-expensive, yet higher-slagging coals such as ILB

TIFI MP™

- Furnace chemical injection program
- Uses two reagents for the reduction of SO_2

TIFI Flux™

- Specifically designed for cyclone boilers
- Focused on burning PRB and other low iron coals

TIFI BlueCat™

- Copper based product
- Used to lower carbon monoxide (CO) and unburned coal (LOI)
- Can be used in combination with TIFI MP to provide SO_2 trim control

TIFI Hybrid™

- Designed for oil-fired boilers
- Uses a combination of TIFI MG combined with in-fuel injection

TCI™

- Designed principally for boilers in the waste-to-energy (WTE) industry
- Inhibits corrosion and slag build-up

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Air Pollution Control Technologies

APC Technology Overview

Combustion

LNB

- 40-60% NO_x Reduction
- Industrial & utility applications
- Upgrades to existing burners available

OFA

- 35-70% NO_x Reduction over Low NO_x burners
- Unique port design enhances mixing to limit impact on combustion efficiency

Post-Combustion

SNCR

- 20-50% NO_x Reduction
- Urea-based maximized performance with minimal ammonia slip

ASCR

- 80+% NO_x Reduction
- 30-70% Less capital then traditional SCR

ULTRA

- Proprietary urea conversion process to generate ammonia for SCR systems
- Safer than ammonia
- Compatible with a wide range of urea sources

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NOx Regulations

- Clean Air Interstate Rule
  - 0.15 lb/MMBtu for 2009
  - 0.12 lb/MMBtu by 2015
- Transport Rule (final by mid-2011 for 2012 compliance)
- Transport Rule 2 (final by 2012 for 2014 compliance)
- Carper/Alexander Legislation (2011?)
- Boiler MACT and CISWI Rule
  - MACT Sources < 250MMBtu
  - Final Rule by February 2012 – 3 years to implement
- Other State Options and Rules

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Reducing NOx Emissions

- **Fuel Switching**
- **Combustion Tuning**
- **Combustion Controls**
  - **Low-NOx Burners**
  - **Over-Fired Air**
- **Post-Combustion Controls**
  - **Selective Non-Catalytic Reduction**
    - **Fuel-Rich Reducing Environment**
    - **Fuel-Lean Oxidizing Environment**
  - **Selective Catalytic Reduction**

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Reducing NOx Emissions

- **How to Capture the Strengths?**
- **How do we expand the Limits?**
- **Are there Synergies?**

- **Customized Solutions:**
  - **Emission Requirements**
  - **Existing NOx Controls**
  - **Total Site Emissions: GHG, CO, etc.**
- **A Complete Site Perspective**

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A Complete Site Perspective

- **Coal Specifications**
- **Combustion Systems: Burners & OFA**
- **Furnace Slag / Fouling**
- **Heat Rate and Furnace Efficiency**
- **Unit Capacity Factor**
- **Excess O2 / LOI**
- **Post-Combustion NOx Control**
- **SO2 and SO3**

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NOx Reduction Strategies

- **Cost Effective Total NOx Reduction**
  - Starts with Combustion
  - Capitalize on Synergies of Combining Technologies
  - Get Guaranteed Performance on each Technology

- **Fuel Tech Advanced SCR (ASCR)**
  - LNB/OFA
  - SNCR
  - Reduced SO_3 Levels
  - ASCR catalyst will provide Hg Oxidation
  - Reduced On-going Catalyst Replacement Costs
  - NOx Reduction at Low Boiler Load and Low SCR Temperature
  - 80-85% Combined NOx Reduction

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NOx Reduction Technologies

Post-Combustion Options without Full Scale SCR

- **SNCR - $NO_xOUT^{®}$ and HERT Systems**
  - **$5-20/kW Capital Cost including Installation**
  - **25-50% Reduction**
- **SNCR/RRI**
  - **$7-22/kW and 40-60% Reduction**
- **ASCR™ Advanced SCR Systems**
  - **$30-75/kW and 65-85% Reduction**

Full Scale SCR Technology

- **Up to $300+/kW with *85-90% Reduction***
- **Fuel Tech Option for Safe Urea Reagent Supply – ULTRA™ ($2-3M Capital)**

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NOx Reduction Technologies – Summary

- **Low Capital Cost NOx Reduction Solutions**
- **Guaranteed NOx Reduction Process Performance and Compliance Assurance**
- **Complete Plant/Process Integration & Seamless Control**
- **Minimal Maintenance Requirements & Proven System Reliability**
- **Full Line of NOx Control Solutions**
- **More Than 25 Years Serving Owners of Power and Steam Generating Facilities**

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APC Installed Experience

- **Advanced Combustion Systems**
  - Over 100 Units to Date for Low NOx Burners, OFA, and Combustion Optimization from 20 MW to 1200 MW
- **NOxOUT® and HERT™ SNCR Systems**
  - Over 600 Units to Date, With > 100 Utility Units
  - All Combustion and Fuel Types
- **NOxOUT ULTRA® Systems**
  - Over 24 Units to Date, 5 to 1,250 PPH of SCR Reagent Feed Systems
- **SCR Design and Modeling Services**
  - Over 55,000 MW's of SCR Design, 20,000 MW's of AIG Tuning
  - Modeling Solutions for Scrubbers, ESPs, FF, Dry Sorbent, HXs, Etc.

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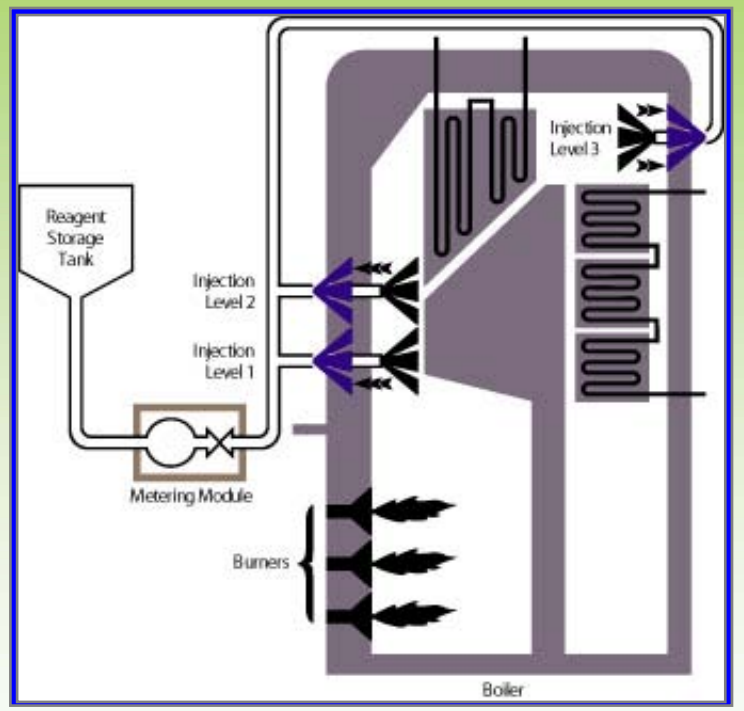
Selective Non-Catalytic Reduction (SNCR)

SNCR Technology Overview: NOxOUT® and HERT™ Systems

- **In-furnace, Post-combustion NO_x Control**
- **Injection of Urea in Upper Furnace**
- **Process Reaction Temperature Range: 1600°F to 2200°F**
- **NO_x Reduction Range**
  - **Utility Boilers: 25 to 50%**
  - **Industrial Boilers: 30 to 70%**



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Selective Non-Catalytic Reduction

SNCR Process Chemical Reactions

(1) $4NO + 2CO(NH2)_2 + O_2 \Rightarrow 4N_2 + 4H_2O + 2CO_2$

(2) $2NO_2 + 2CO(NH2)_2 + O_2 \Rightarrow 3N_2 + 4H_2O + 2CO_2$

Nitrogen Oxides + Urea + Oxygen ⇨ Nitrogen + Water Vapor + Carbon Dioxide

Typically 95% of NOx is associated with Eq 1

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SNCR Technology Overview

- **In-furnace, Post-combustion Control**
  - **Injection of Aqueous Urea Droplets**
  - **25 – 70% NOx Reduction**
  - **Many Injection Options:**
    - **Compressed Air**
    - **Mechanical**
    - **Multiple Nozzle Lances – Water Cooled**
  - **Package Boilers to Utility Boilers**
  - **Option for Aqueous or Anhydrous Ammonia**

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Advantages of Fuel Tech's SNCR System

- **Guaranteed Proven NOx Reduction**
  - **15 – 35% Utility**
  - **20 – 70% Industrial/Incineration**
  - **Repeatable**
  - **Controlled NH3 Slip**
- **Low Capital Cost**
- **Fast Implementation**
- **Turn On/Off As Needed**
- **Compatible with Other APC Technologies**
  - **LNB/OFA**
  - **ASCR or SCR**
  - **ESP's and Fabric Filters**

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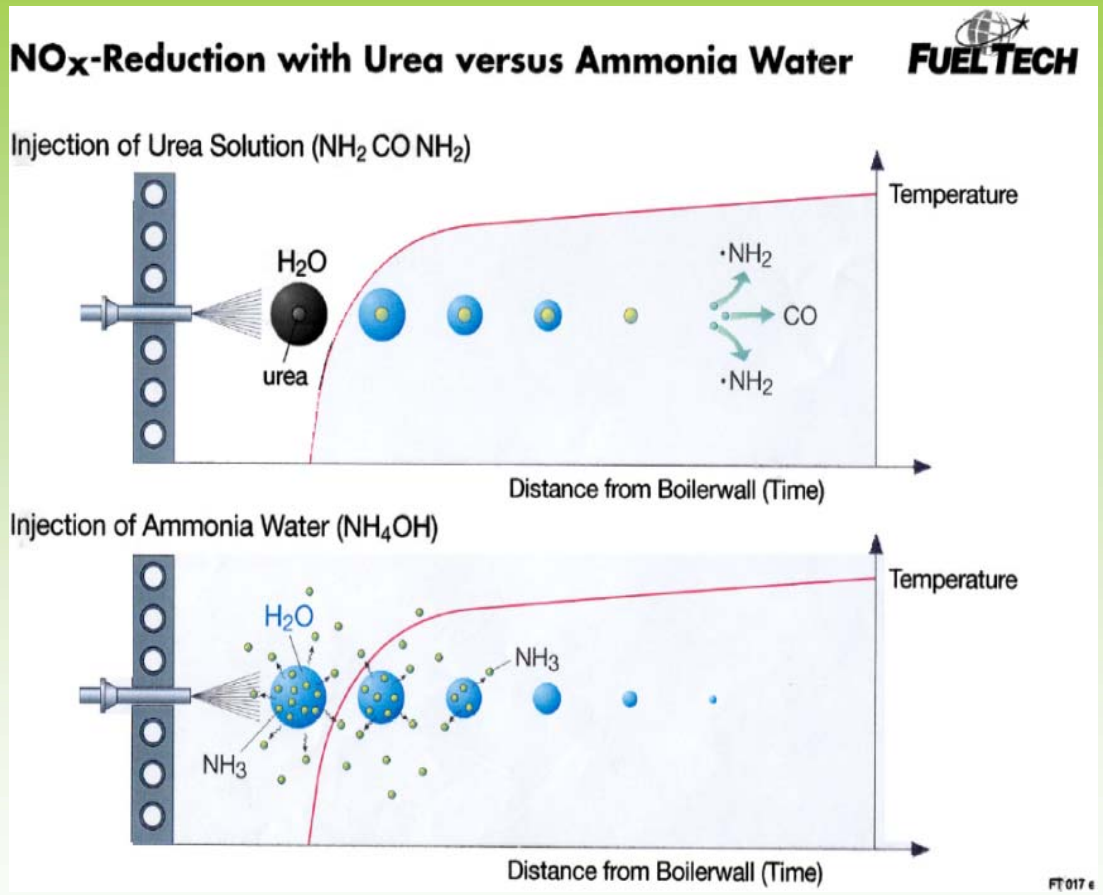
Urea vs. Ammonia for SNCR



Urea droplets formed by FTI injectors are characterized in test facilities using laser Doppler techniques.

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SNCR Boiler and Fuel Experience

Utility Boilers

- T-fired
- Wet Bottom
- Wall Fired
- Cyclone
- Tower

Industrial

- Circulating Fluidized Bed
- Bubbling Fluidized Bed
- Stoker, Grate Fired
- Incinerators
- Industrial

Coal

- Bituminous
- Sub-bituminous
- Lignite

Other Fuels

- Oil – #2 and #6
- Natural Gas
- Refinery Gases (High CO)
- Municipal Solid Waste
- Tire Derived Fuel
- Wood
- Sludge

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SNCR Systems – Industry Experience

- **Electric Utilities**
- **Wood-fired IPPs / CoGen**
- **TDF Plants**
- **Pulp & Paper**
  - Grate-fired
  - Sludge Combustors
  - Recovery Boilers
  - Wellons Boilers
  - Cyclones
- **Refinery Process Furnaces**
- **CO Boilers**
- **Petrochemical Industry**
- **CoGeneration Boilers**
- **Municipal Solid Waste**
- **Process Units**
- **Cement Kilns**

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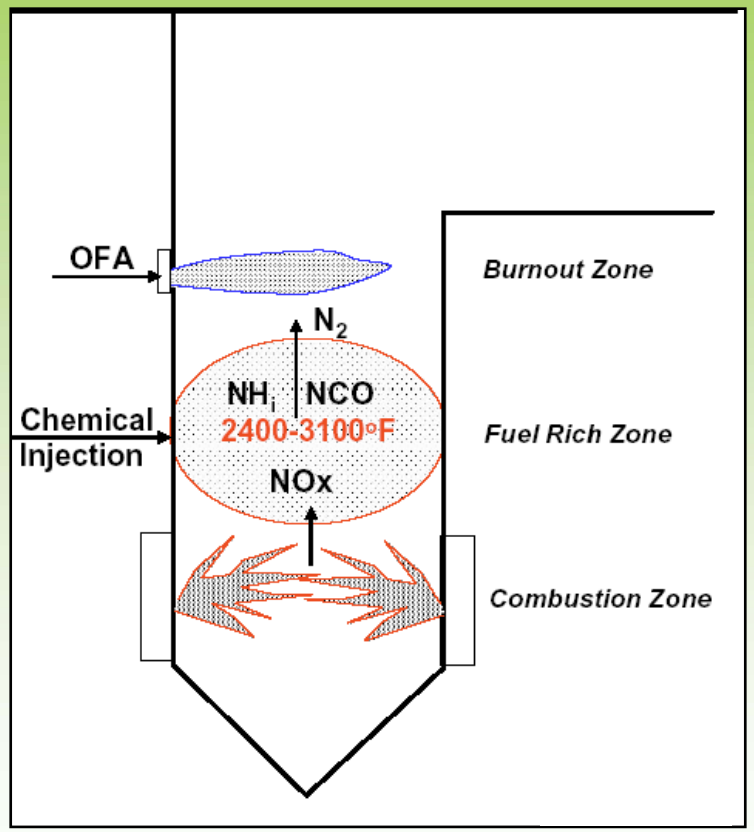
Rich Reagent Injection (RRI) Technology Overview

- 40 to 60% NO_x Reduction Combined with SNCR on Cyclone Boilers
- NO_x Reduction in 30% Range with RRI Only
- Non-catalytic Reduction of NO_x via Urea Injection in Sub-stoichiometric Conditions (SR: 0.85 to 0.95)
- No Reagent Slip Due to High Residence Time and Reagent Oxidation in the Burnout Zone
- Process Reaction Temperature Range: 2600°F to 3100°F
- Technology Licensed from REI



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SNCR PROCESS DESIGN AND MODELING

SNCR Critical Process Parameters

- **Effective Temperature Window for Chemical Release and Reaction – 1600°F to 2200°F, Depending on Application**
- **Temperature too High ⇨ NH2 Oxidation to NOx, Temperature too Low ⇨ Ammonia Slip**
- **Flue Gas Velocity and Residence Time Considerations**
- **Background Gas Composition – NOx, CO, O_2, and Sulfur Content of the Fuel**

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Controlling Risks SNCR:

- **Carefully Target the Injection Zone**
  - **CFD Modeling**
  - **Field Assessments / Demonstrations**
- **Understand the Chemistry**
  - **Urea and ammonia Mechanisms**
  - **Ammonium Bisulfate Formation**
- **Refer to Experience Database**
  - **More Than 500 Applications**
  - **More Than 100 Utility Furnaces**

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SNCR Process Design

Computational Fluid Dynamics (CFD)

Used to Define Effective Boundaries of Critical Process Parameters, Test Effectiveness of Distribution Strategies, Identify/Locate/Define Gas Species Concentrations – Physical Unit Data (Drawings, etc.) and Field Testing as Input

Chemical Kinetic Model (CKM)

Used to Calculate Each Specific Time/Temperature Reduction Reaction – Overlay the SNCR Process on the CFD

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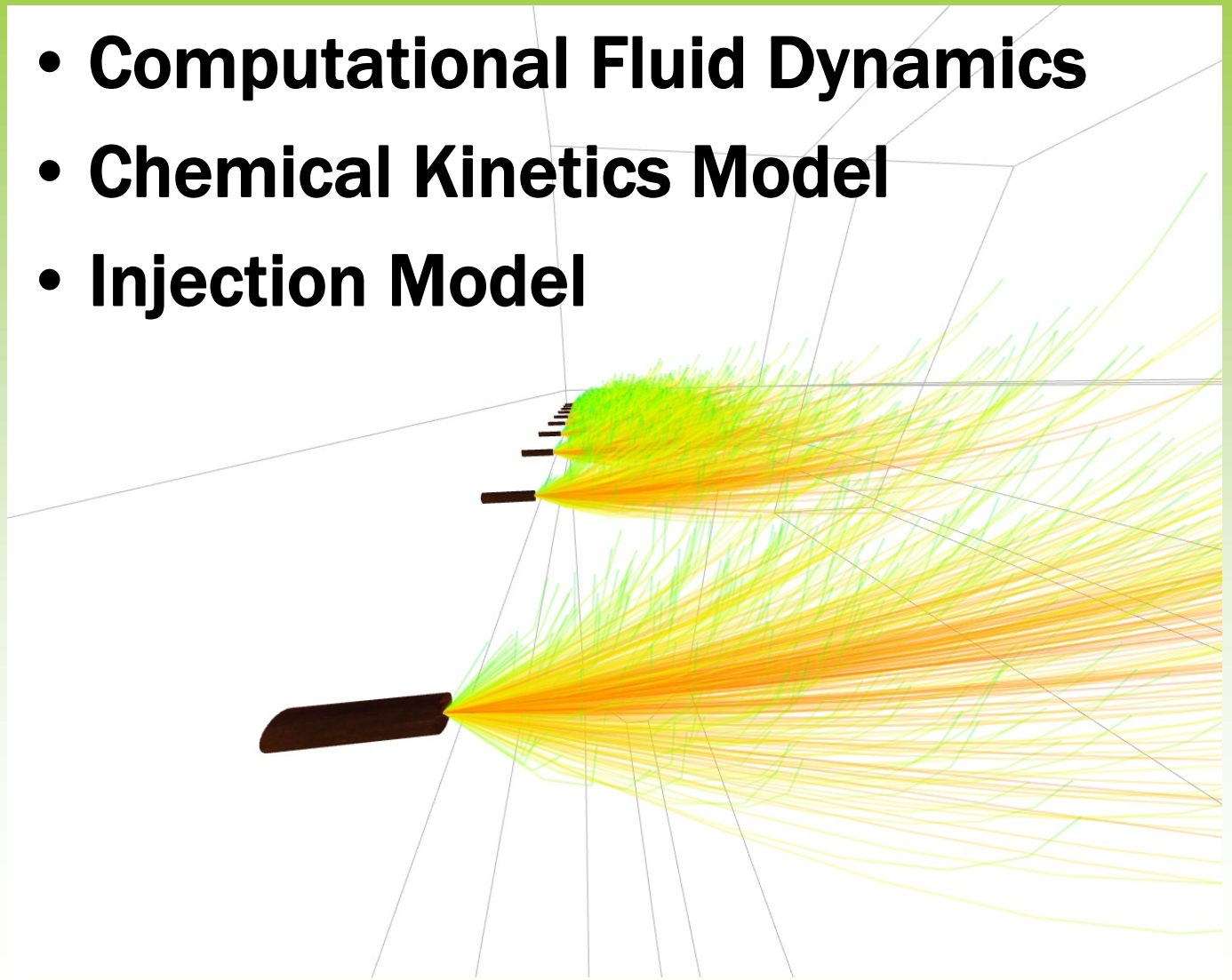
SNCR Process Application

- **Computational Fluid Dynamics**
- **Chemical Kinetics Model**
- **Injection Model**



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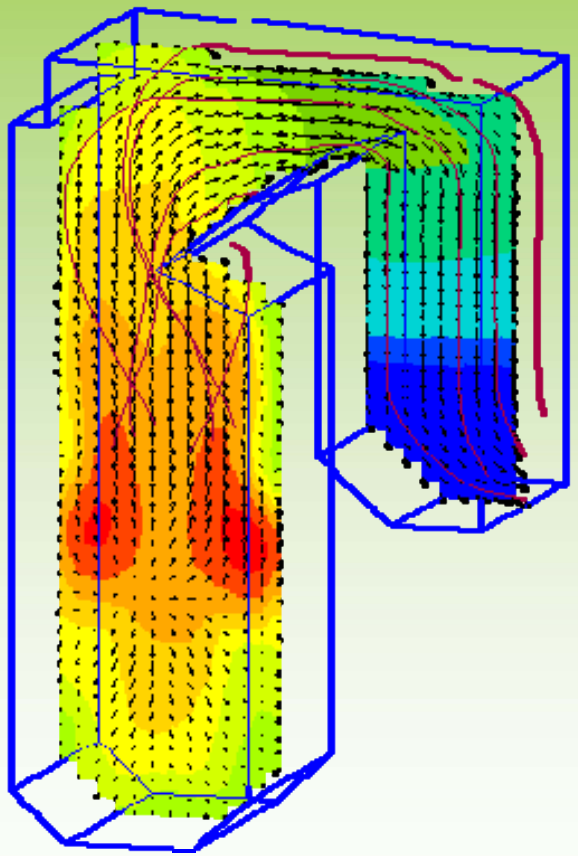
SNCR Process Modeling Steps



Step 1: Define the Unit Geometry

Step 2: Block Out Obstructed Cells and Faces

Step 3: Define Mass and Heat Sources

Step 4: Solve for Flue Gas Temperatures and Velocities

Step 5: Generate Temperature Versus Residence Time Data for CKM

Step 6: Identify Temperature Limits for Effective NOxOUT Performance

Step 7: Select Injector Locations and Spray Characteristics

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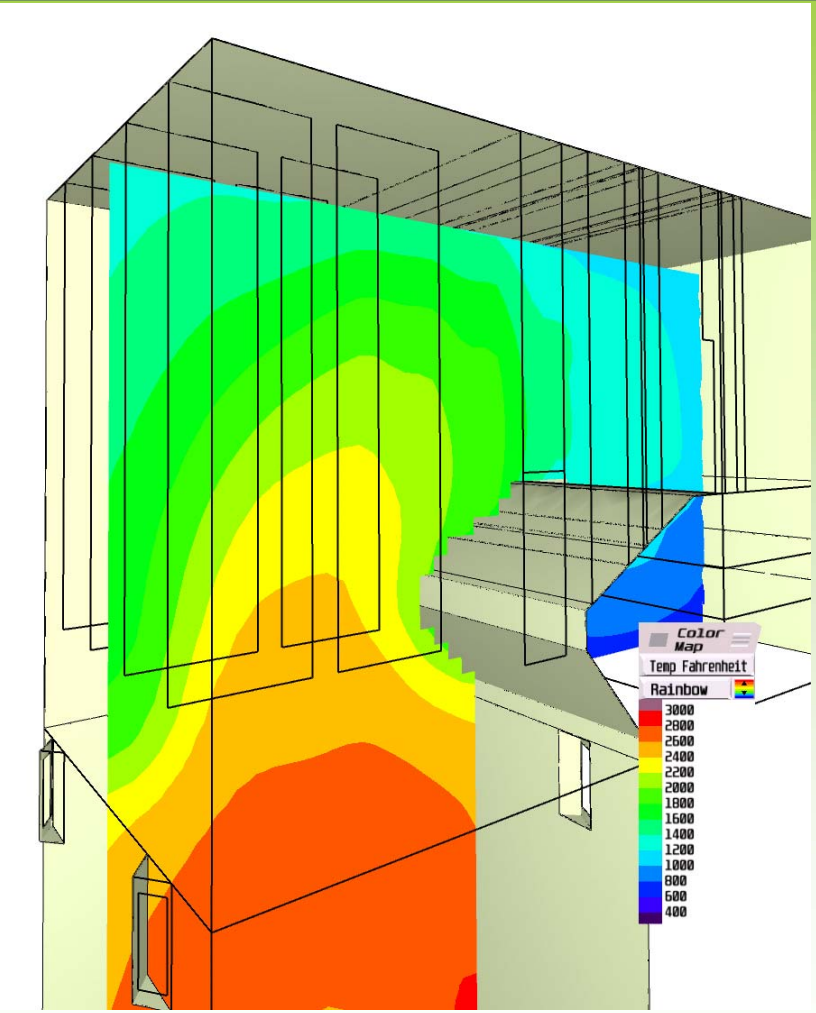
Baseline Testing (HVT) for CFD/CKM



- High Velocity Thermocouple Suction Pyrometer and Portable Gas Analyzer Used to Gather Temperature and Flue Gas Composition
- Develop Grid of Measurements Based on Actual Operating Conditions
- Build CFD Model Using Data Gathered from Field
- Overlay SNCR Process on CFD to Determine Reagent Distribution and Performance

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Temperature and Species Mapping

- Three (3) Boiler Loads
  - Full, Mid, and Low Load Depending on NOx Removal Requirements
- Typical One (1) Week Service
  - One (1) Field Engineer, Two (2) Technicians
- Fuel Tech to Provide All Equipment Including High Velocity Thermocouple (HVT), Cooling Water Pumps, Hoses, and Analyzers
- Scope By Others
  - Maintain Steady State Boiler Conditions for 4 – 6 Hours per Load
  - DCS Data during Testing
  - Water and Electrical Hook-ups
  - Observation Doors or Ports for HVT Testing
  - Fuel and Operational Data, Boiler Drawings

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