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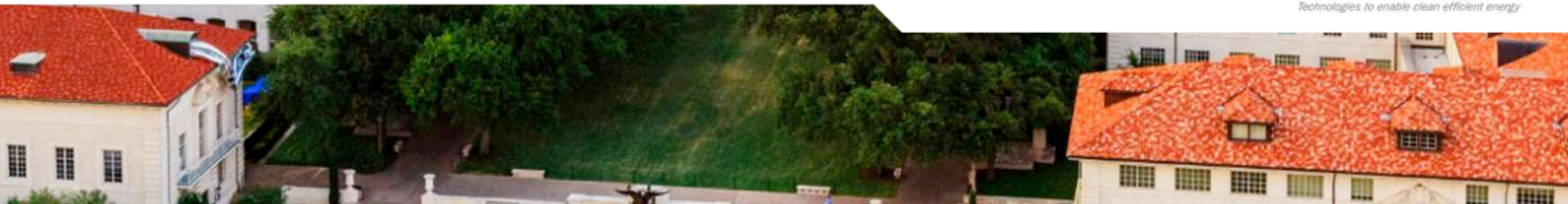
# UT Austin

## Efficiency Improvements & ULTRA™ System

THE UNIVERSITY OF TEXAS AT AUSTIN

FUEL TECH
Technologies to enable clean efficient energy



# Agenda

- University of Texas at Austin
  - Utilities & Energy Management Overview
  - Achievements in Energy Efficiency
  - 2008 CHP Upgrade, Equipment Description, Emissions Control
- Reagent Decision for SCR
  - Urea versus Ammonia, Safety and Risk Considerations
  - On-site Urea Conversion Systems
- ULTRA™ System
  - Process Description
  - System Scope
  - Startup, Operational History, Current Status
- Summary

## Investments

- $33 Million – Cash Based – UEM Budget
- $138 Million – Revenue Bonds

## Electricity Total Capacity

- Increased - 85 MW to 137 MW

## Cooling Total Capacity

- Increased From 30.5K tons to 54K tons
- Includes 4 million gallon TES

## Steam Plant Capacity

- Increased From 1.1 to 1.2 million lbs

Efficient Equipment Matched to Campus Loads

## Investments

- $33 Million – Cash Based
- $138 Million – Revenue

## Campus Growth 4.2 million GSF vs. 1996

- Plant Efficiency Improved 40%
- Fuel Use Reduced to 1976 levels (9 million More GSF)
- Water for Generation Decreased 25%
- Sewer Costs Decreased by 51%
- 99.9998 % Reliability for 40 years

## Payback on Investments since 1996

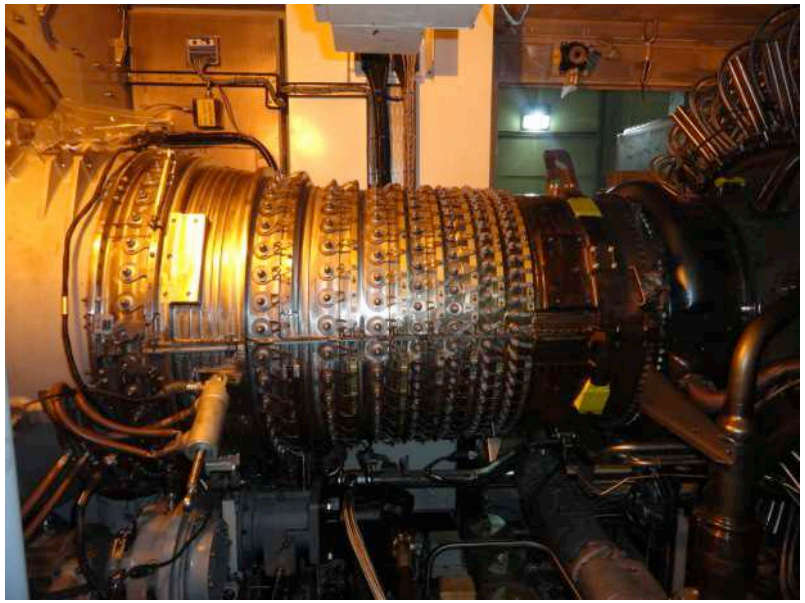
- $75 .2 Million – Avoided Cost Due to Efficiency Improvements
- Straight Line Payback of $138 million is in 2021 @ $4/mmbtu gas cost

## Since 2006 as By-Product of Efficiency

- $3.7 Million – Avoided Water and Sewer Costs (464 M Gal)

# GAS TURBINE #10 AND HEAT RECOVERY STEAM GENERATOR #10

32 MW GE LM2500 + DLE GT generator w/Heat Recovery Steam Generator (HRSG) & SCR with Cormetech CM-21 Catalyst

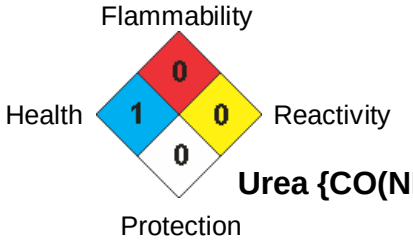


# SCR System Reagent Options

- **Anhydrous Ammonia**
  - Least Expensive (Coming in the Gate)
  - Extremely Hazardous Chemical, Highest Risk
  - Requires RMP, Extensive Safety Training, Evacuation Plan


**Ammonia {$NH_3$}**

- **Aqueous Ammonia**
  - 29% Concentration – Limited Availability, No OSHA Relief
  - 19% Concentration – More Widely Available, No RMP
- **Urea for On-Site Ammonia Generation**
  - Significant Safety Advantages
  - Worldwide Commodity
  - No Impact on Catalyst Life or SCR Performance
  - Installed on Hundreds of Units Around the World

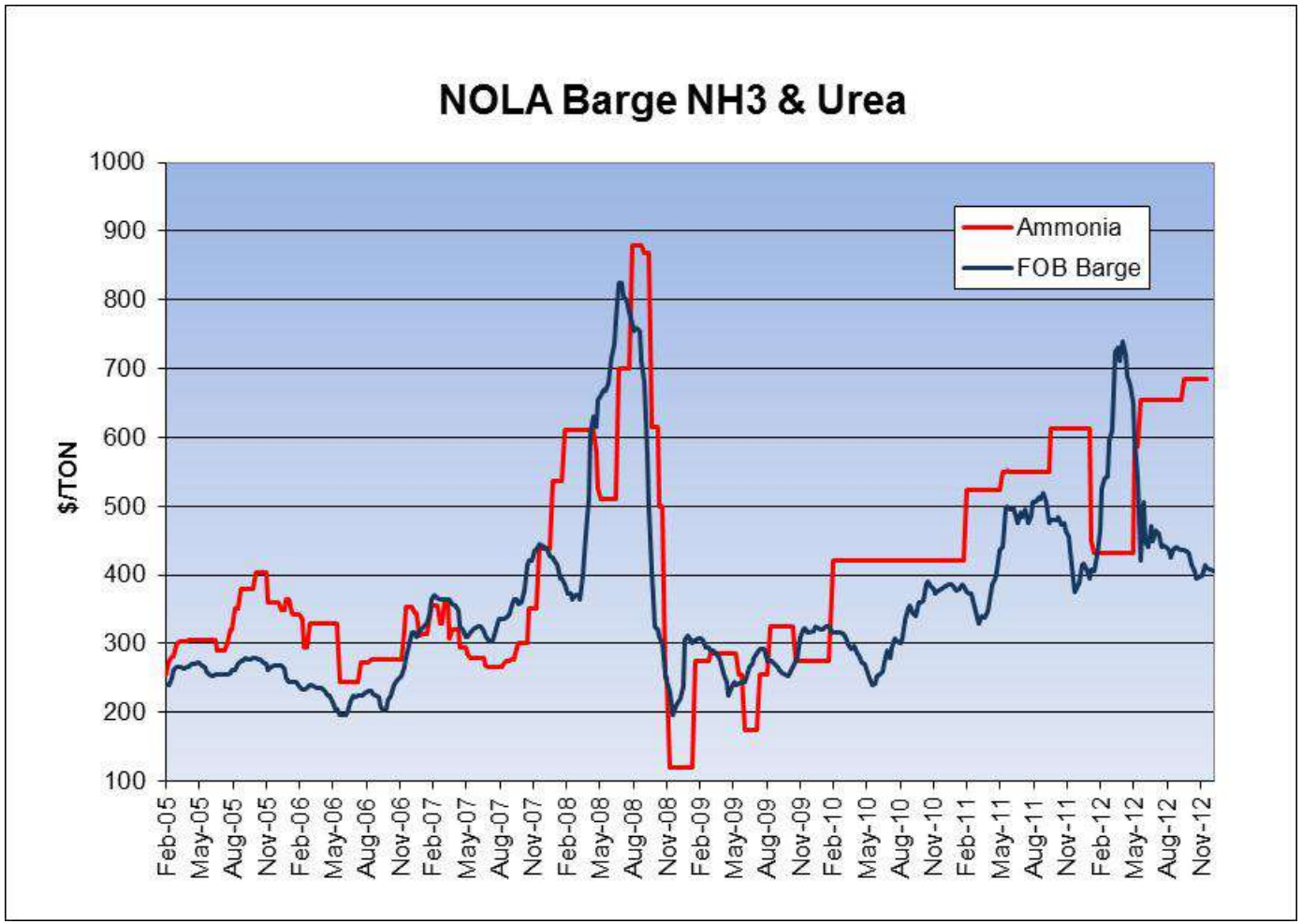



**Urea {$CO(NH_2)2$}**

# Urea vs. Ammonia – Other Considerations

- **Safety**
  - Safety can be Engineered into the Design, Reducing but Not Eliminating Risk
- **Natural Gas Pricing**
  - Natural Gas is the Raw Material Used for Fertilizer Production
  - Downward Trend in NG Price May Result in Increased Domestic Fertilizer Production, Majority Brought in From Overseas
- **On-site Ammonia Storage**
  - Anhydrous is Considered a “Highly Hazardous Chemical” by the DHS, Toxic Inhalation Hazard
- **Transportation**
  - “Chain of Custody” Regulations Put Risk in the Hands of the Transporter from Source to Point of Delivery

# Historical Bulk Urea and Ammonia Pricing



# ULTRA™: On-site Urea Conversion

## Thermal Decomposition Process

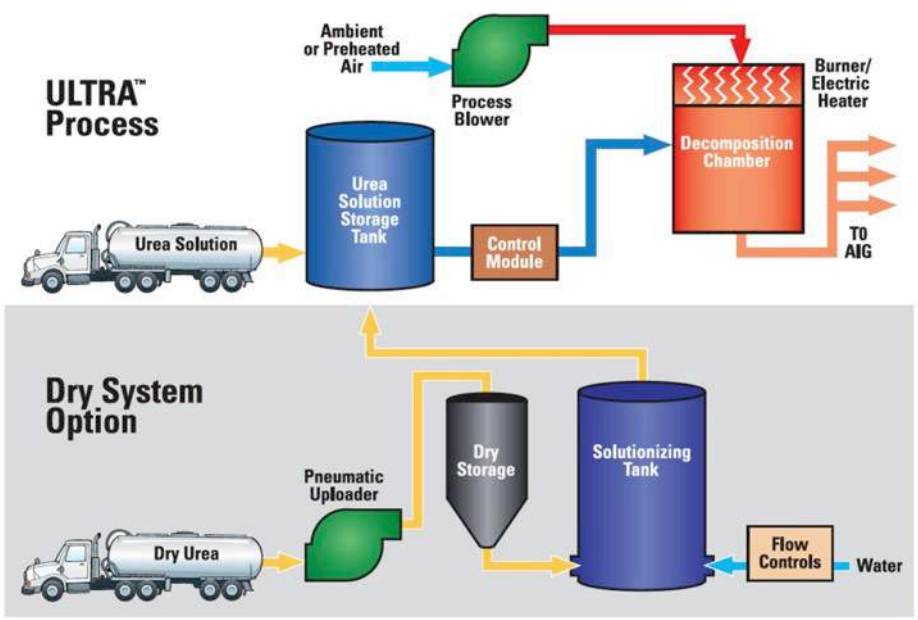


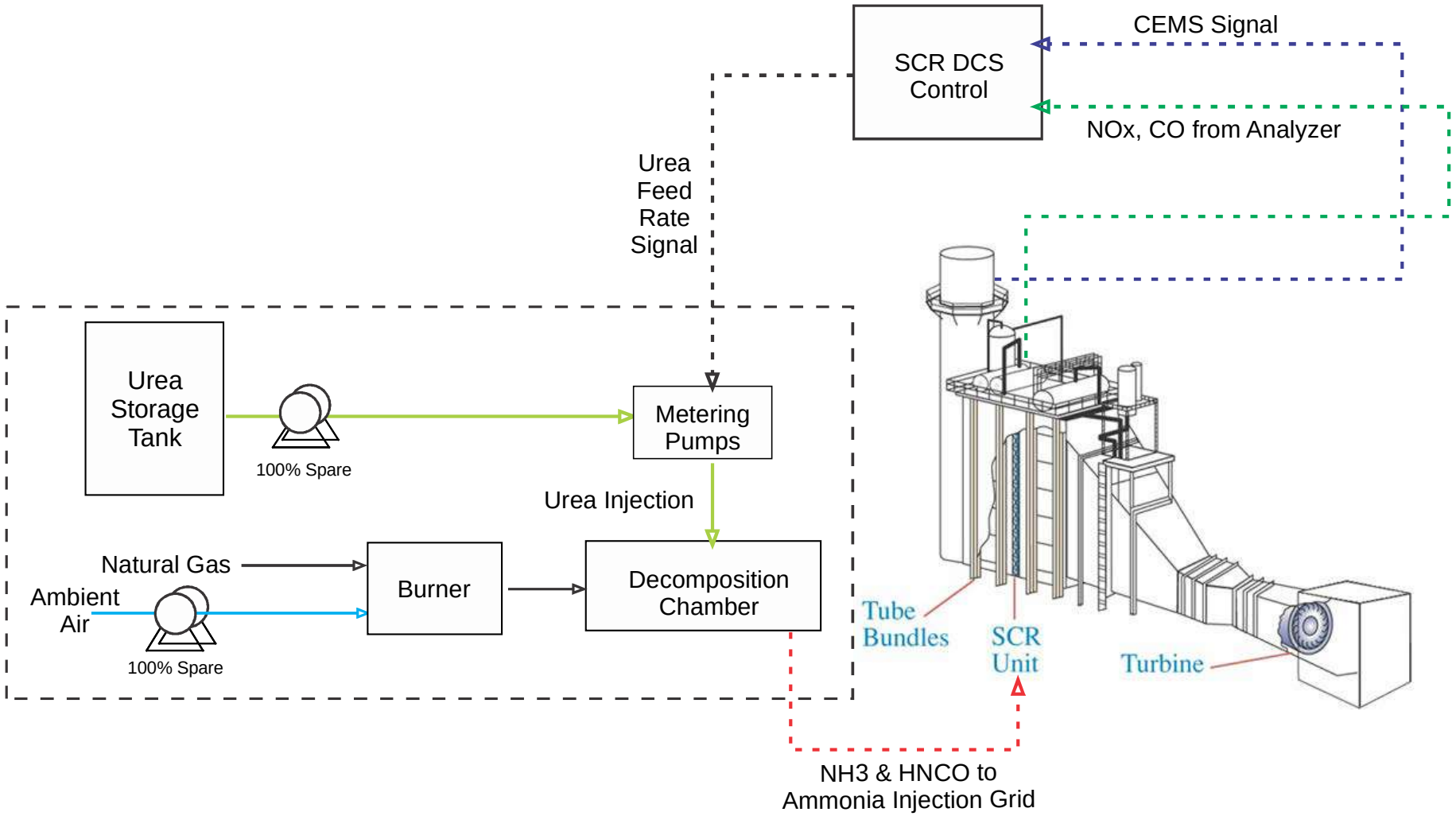

*Image Courtesy of Fuel Tech, Inc.*

- Energy Required for Decomposition Typically Provided by Natural Gas or Oil-fired Burner, Electric Heater
- Urea Flow Adjusted by $NH_3$ Demand Signal Sent to the Metering Pumps
- Fast Response, Good Turndown

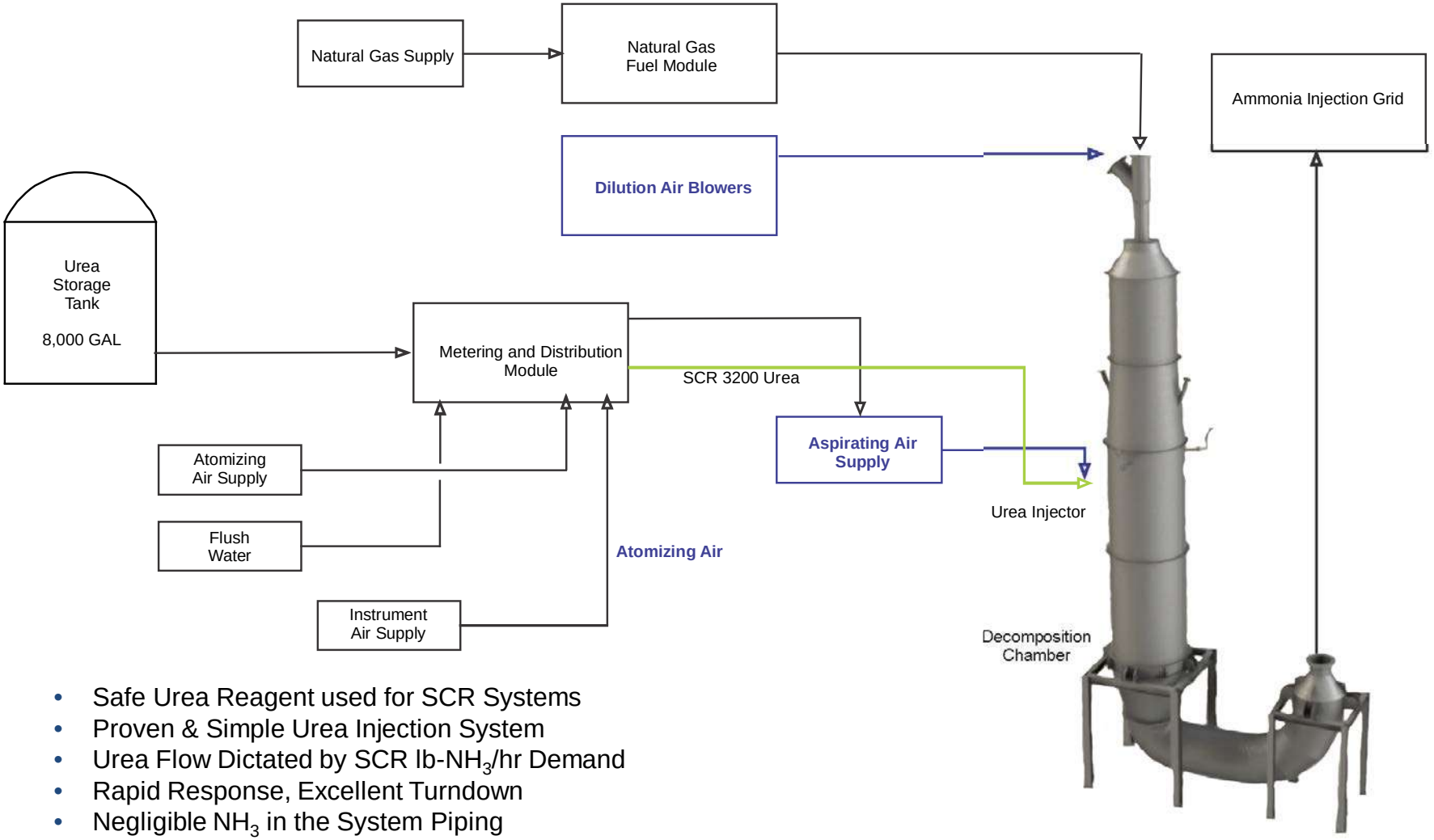
# Urea Supply Considerations

- Urea Can Be Sourced in Solid Form
  - Prill or Granular Forms
  - Solid urea can be Solutionized On-site
- Urea Can Be Sourced as High Purity Aqueous Solution
- Economics favor solutionizing with larger systems
- ULTRA process compatible with a wide range of urea sources
  - No special urea needed which is often required with other processes
  - MDU coating used to prevent caking of dry urea is acceptable for ULTRA
  - Urea specifications allow for global sourcing for best pricing and availability

# ULTRA™ and SCR Process Schematic



# ULTRA™ System Schematic



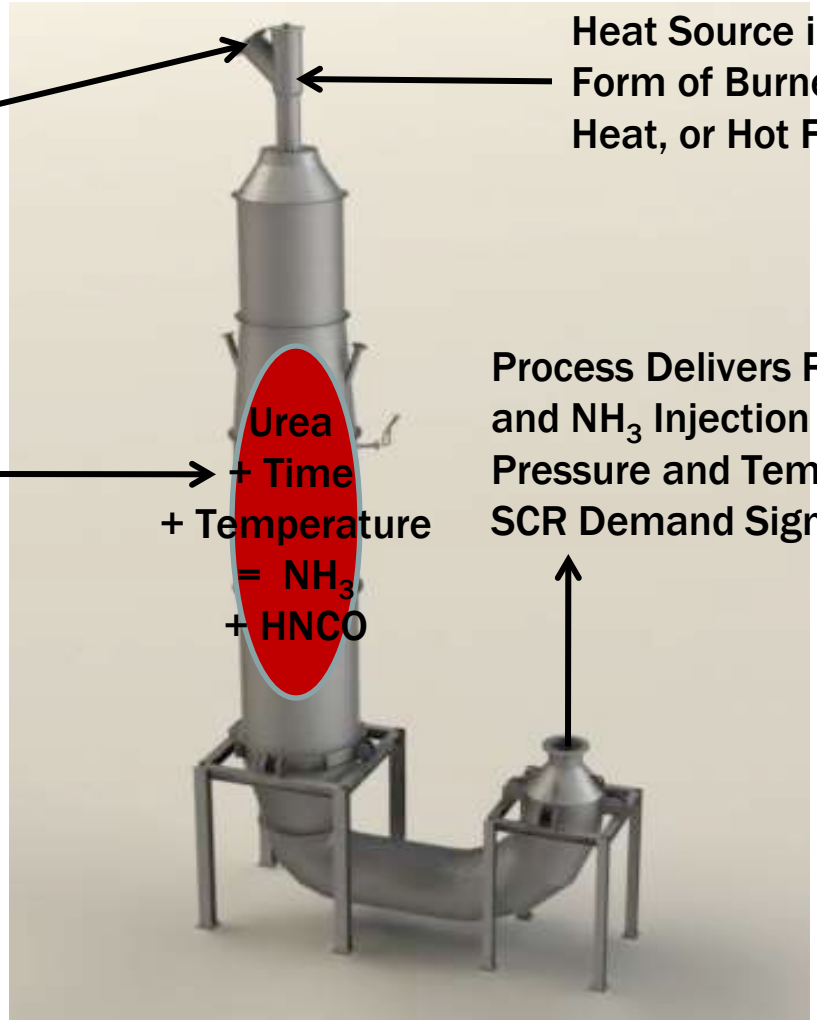

- Safe Urea Reagent used for SCR Systems
- Proven & Simple Urea Injection System
- Urea Flow Dictated by SCR lb-$NH_3$/hr Demand
- Rapid Response, Excellent Turndown
- Negligible $NH_3$ in the System Piping

# Thermal Decomposition of Urea

Carrier Medium: Ambient Air, Clean Flue Gas

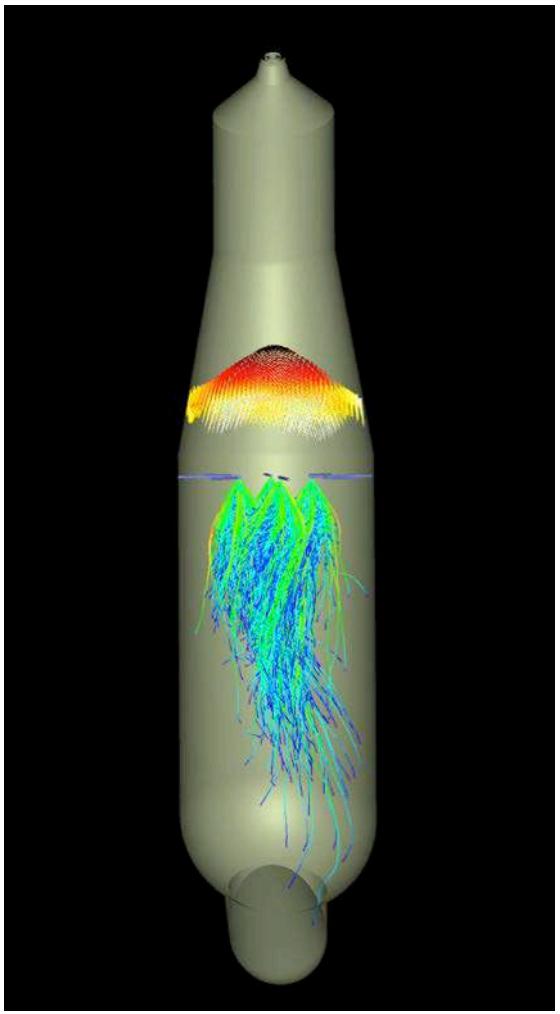
Heat Source in the Form of Burner, Electric Heat, or Hot Flue Gas

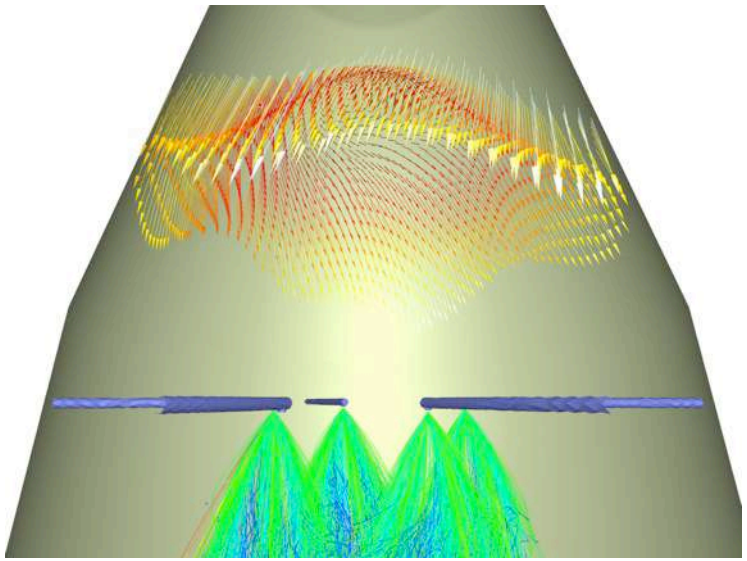
Injection of Aqueous Urea in Temperature and Time Dependent Chamber – Fast Load Following Capabilities




Process Delivers Reagent to Static Mixer and $NH_3$ Injection Grid (AIG) at Required Pressure and Temperature Based on SCR Demand Signal

# ULTRA™ Process Modeling





- **Computational Fluid Dynamics (CFD) Modeling of Decomposition Chamber**
- **Modeling of Temperature, Residence Time, and Droplet Dispersion**
- **Evaluation of Urea Injection Strategies**

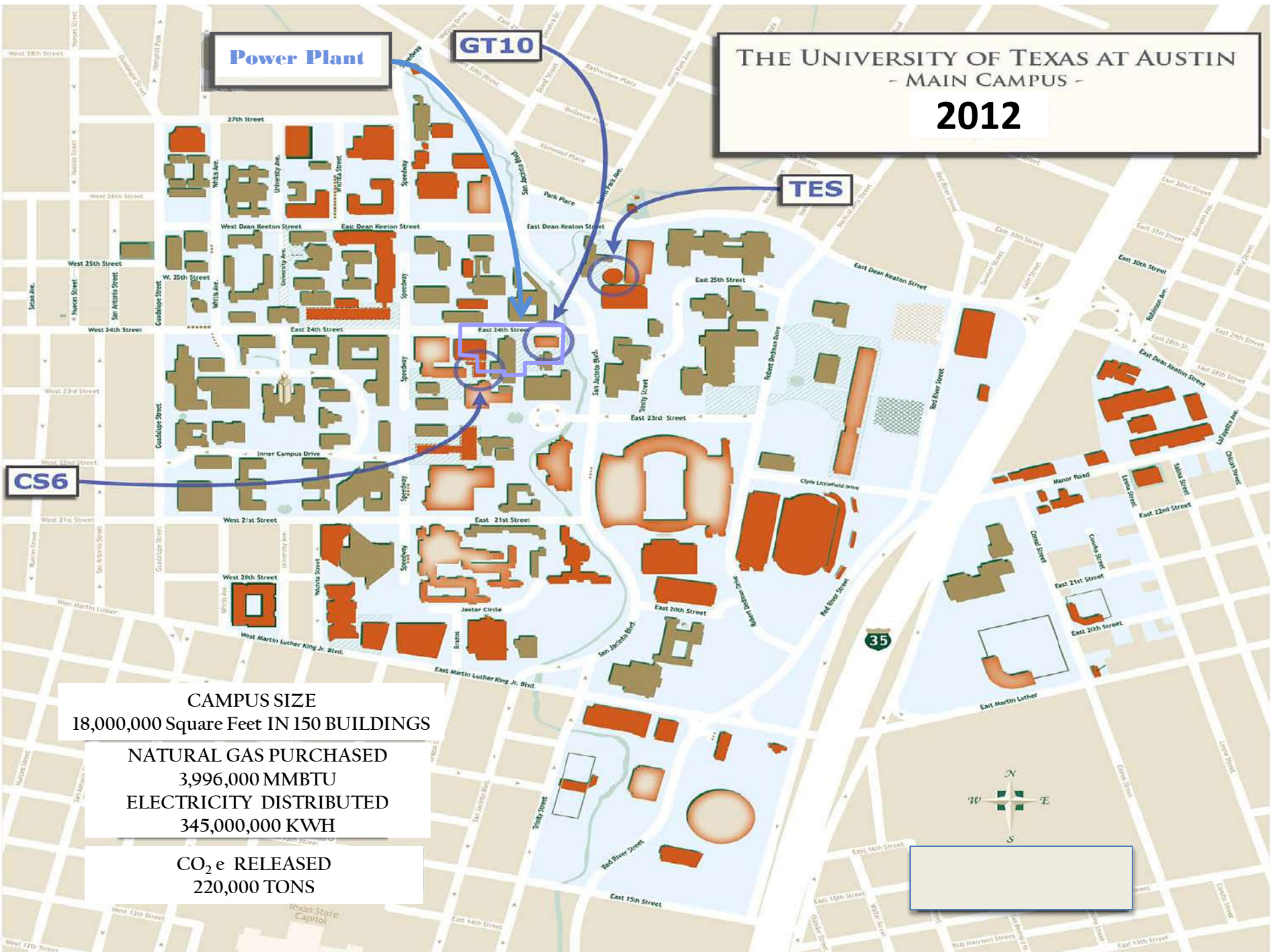
# ULTRA™ System Configuration

- System Designed for 40% or 32% Urea (40% Initial Operation)
- 24.7 lb-$NH_3$/hr maximum and 2.47 lb-$NH_3$/hr minimum
- 8,000 Gallon FRP Concentrated Urea Storage Tank
- Two (2) 100% Dilution Air Blowers
- One (1) Metering and Distribution Module
- One (1) Natural Gas Burner
- One (1) Decomposition Chamber (2’ Diameter × 20’ Tall)
- Two (2) Urea Injectors
- ControlLogix PLC Controls
- Construction, Startup and Optimization Support

# ULTRA™ System Illustration

# Urea Conversion System Selection

- Constrained Site
- 50,000 Students in the Region
- Campus Safety is Paramount


Power Plant
GT10
TES
CS6
THE UNIVERSITY OF TEXAS AT AUSTIN
- MAIN CAMPUS -
2012
CAMPUS SIZE
18,000,000 Square Feet IN 150 BUILDINGS
NATURAL GAS PURCHASED
3,996,000 MMBTU
ELECTRICITY DISTRIBUTED
345,000,000 KWH
$CO_2$ e RELEASED
220,000 TONS

# Ammonia Risks

## Anhydrous Ammonia

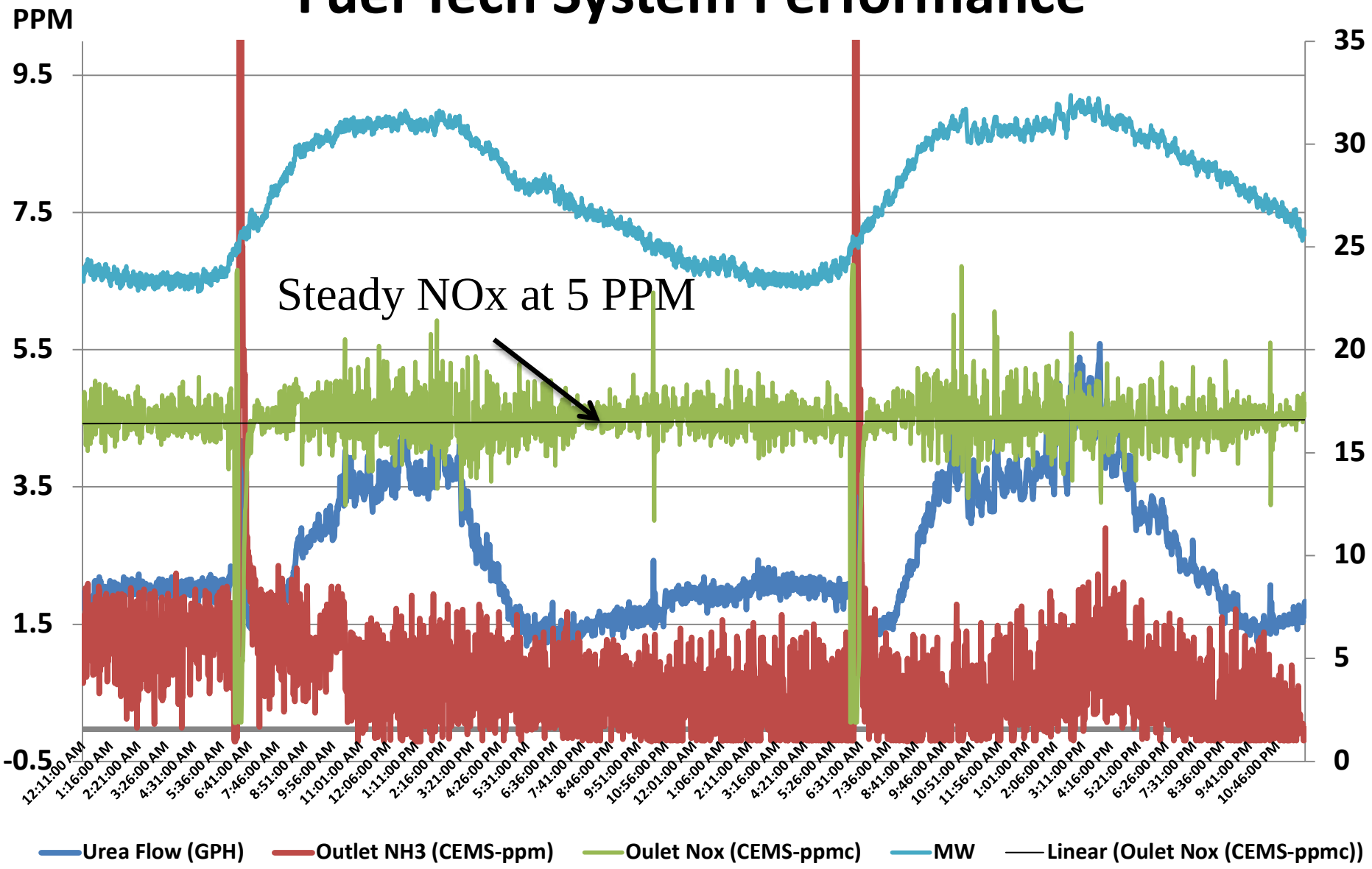
| Exposure (ppm) | Effect on the Body | Permissible Exposure |
|---|---|---|
| 50 ppm | Detectable by most people | No injury from prolonged, or repeated exposure |
| 134 ppm | Irritation of nose and throat | Eight hours maximum exposure |
| 700 ppm | Coughing, severe eye irritation, may lead to loss of sight | One hour maximum exposure |
| 1,700 ppm | Serious lung damage, death unless treated | No exposure permissible |
| 2,000 ppm | Skin blisters and burns within seconds | No exposure permissible |
| 5,000 ppm | Suffocation within minutes | No exposure permissible |

## Aqueous Ammonia Not Much Better

# Urea Conversion System Selection

- Safest and Most Effective Alternative to the Use of Ammonia in our Campus
- Met Overall Performance and Turndown Requirements
- Satisfied Need to Work within a Limited Footprint
- Accepted by SCR and Catalyst Providers
- Proven Track Record in Similar Applications
- Competitive Economics

# Fuel Tech System Performance

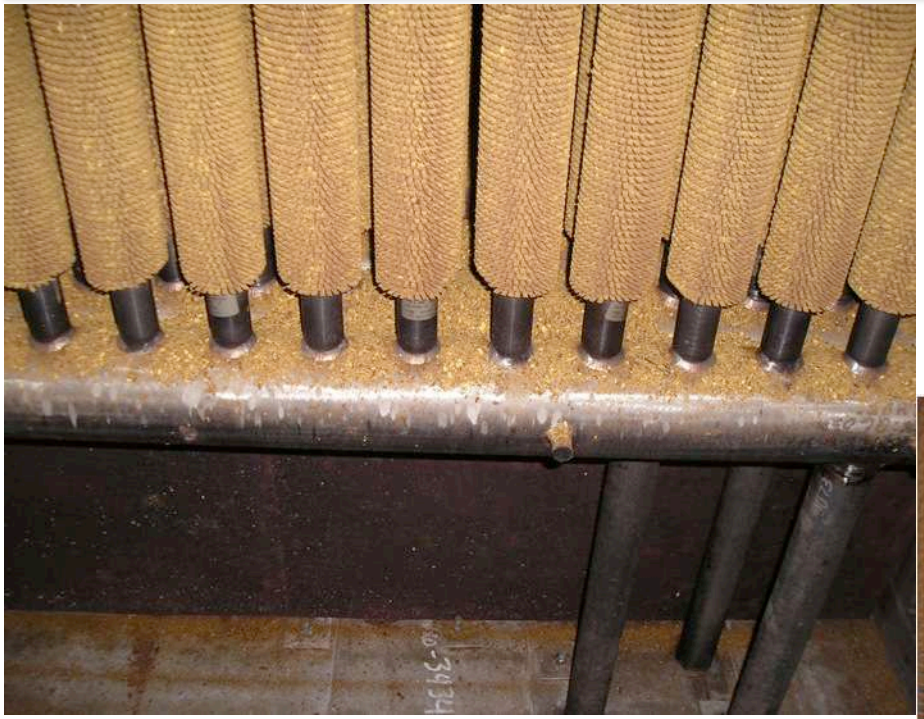


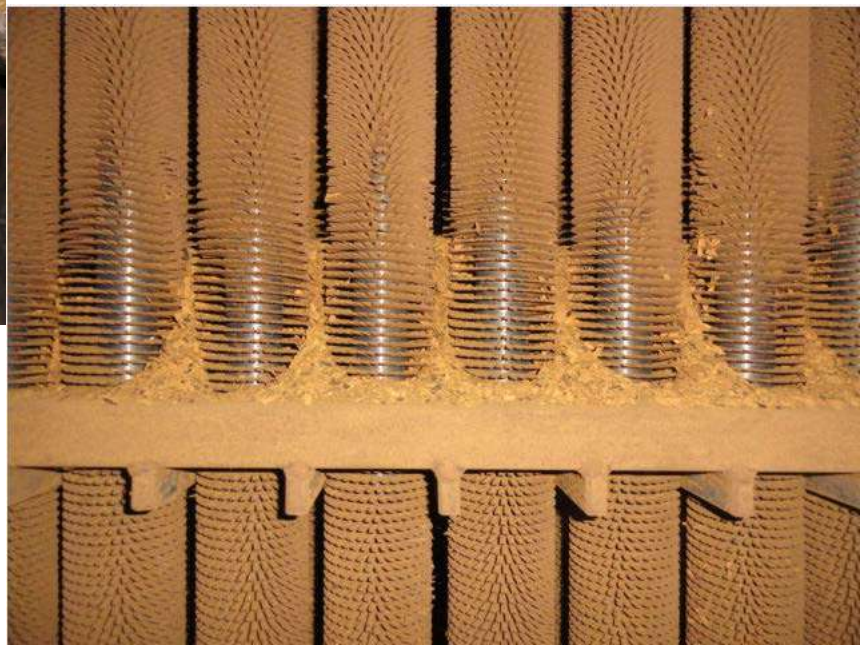

FUEL TECH
Technologies to enable clean efficient energy

## Operating Since 2008

THE UNIVERSITY OF TEXAS AT AUSTIN

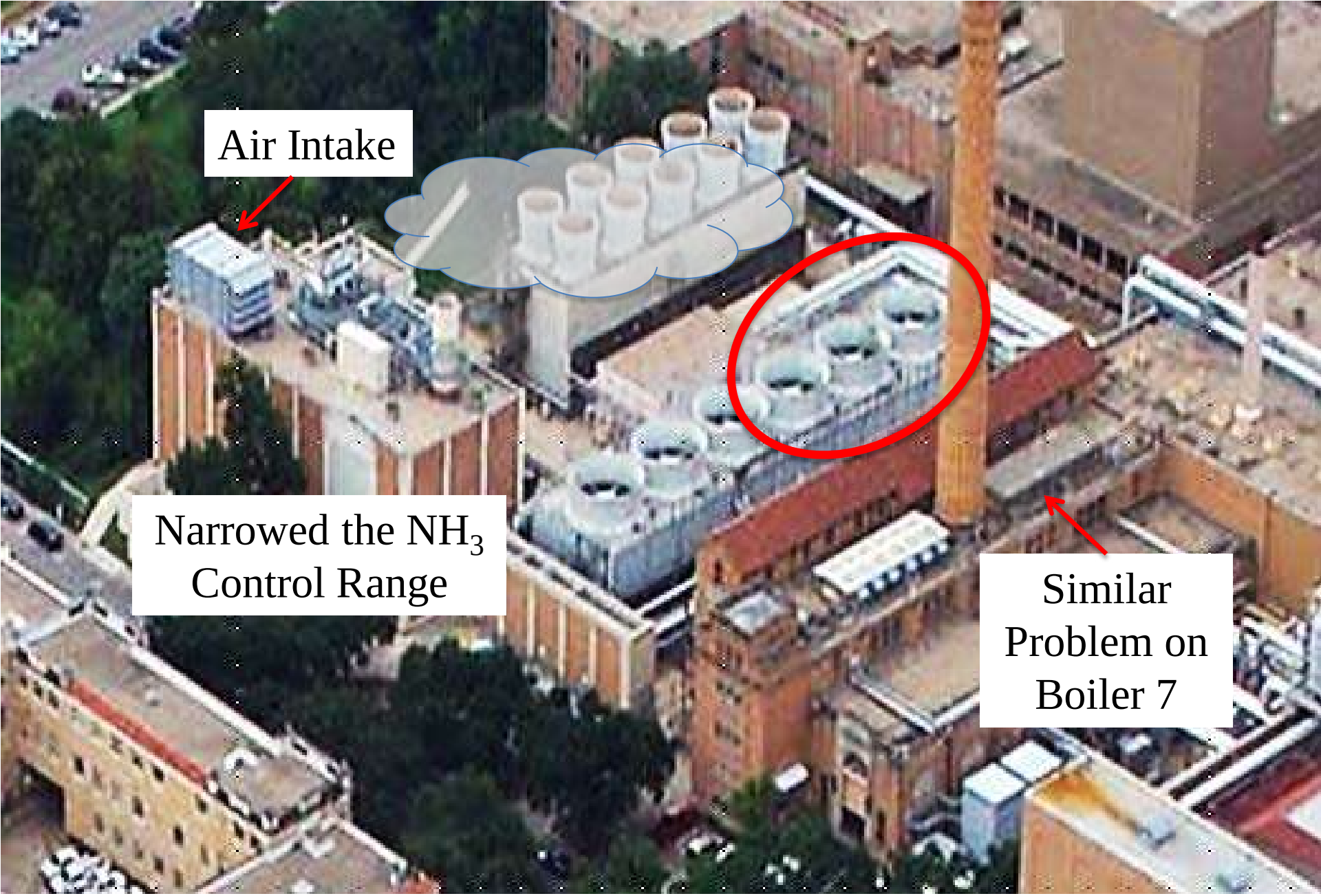
# Deposit Problem





# Operational/Equipment Issues and Lessons Learned

- Deposits created as Ammonium bisulfate
  - Formed at about 400° F
  - React with tube material to form iron sulfate – corrosion
- Confusion on where the sulfur was coming from
  - Analyzed Natural Gas – nothing
  - Analyzed Urea – nothing
- Most likely the sulfur is a result of cooling tower drift
  - Use Sulfuric Acid for PH control


Air Intake
Narrowed the $NH_3$ Control Range
Similar Problem on Boiler 7

# Summary

- ULTRA System Operating Since 2008
- Was the Right Choice for our Application
- No Issues with Urea Availability or Delivery
- Good Support for Start-up Issues, Minor Equipment Issues and Ongoing
- No Emissions Issues