UT Austin
Efficiency Improvements & ULTRA™ System
Agenda

• University of Texas at Austin
  o Utilities & Energy Management Overview
  o Achievements in Energy Efficiency
  o 2008 CHP Upgrade, Equipment Description, Emissions Control

• Reagent Decision for SCR
  o Urea versus Ammonia, Safety and Risk Considerations
  o On-site Urea Conversion Systems

• ULTRA™ System
  o Process Description
  o System Scope
  o 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

- **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 vs. Ammonia – Other Considerations

• Safety
  o Safety can be Engineered into the Design, Reducing but Not Eliminating Risk

• Natural Gas Pricing
  o Natural Gas is the Raw Material Used for Fertilizer Production
  o Downward Trend in NG Price May Result in Increased Domestic Fertilizer Production, Majority Brought in From Overseas

• On-site Ammonia Storage
  o Anhydrous is Considered a “Highly Hazardous Chemical” by the DHS, Toxic Inhalation Hazard

• Transportation
  o “Chain of Custody” Regulations Put Risk in the Hands of the Transporter from Source to Point of Delivery
Historical Bulk Urea and Ammonia Pricing

NOLA Barge NH3 & Urea

- Ammonia
- FOB Barge

$/TUM
Temperature Decomposition Process

- Energy Required for Decomposition Typically Provided by Natural Gas or Oil-fired Burner, Electric Heater
- Urea Flow Adjusted by NH₃ Demand Signal Sent to the Metering Pumps
- Fast Response, Good Turndown

Image Courtesy of Fuel Tech, Inc.
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

- Urea Storage Tank
- Urea Feed Rate Signal
- SCR DCS Control
- CEMS Signal
- NOx, CO from Analyzer
- Metering Pumps
- Urea Injection
- Burner
- Decomposition Chamber
- Natural Gas
- Ambient Air
- Tube Bundles
- SCR Unit
- Turbine
- NH₃ & HNCO to Ammonia Injection Grid

100% Spare
ULTRA™ System Schematic

- Safe Urea Reagent used for SCR Systems
- Proven & Simple Urea Injection System
- Urea Flow Dictated by SCR lb-NH₃/hr Demand
- Rapid Response, Excellent Turndown
- Negligible NH₃ 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 NH₃ Injection Grid (AIG) at Required Pressure and Temperature Based on SCR Demand Signal

Urea + Time + Temperature = NH₃ + HNCO
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
CAMPUS SIZE
18,000,000 Square Feet IN 150 BUILDINGS

NATURAL GAS PURCHASED
3,996,000 MMBTU

ELECTRICITY DISTRIBUTED
345,000,000 KWH

CO₂e RELEASED
220,000 TONS
# Ammonia Risks

## Anhydrous Ammonia

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

## 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

Steady NOx at 5 PPM

- Urea Flow (GPH)
- Outlet NH3 (CEMS-ppm)
- Outlet Nox (CEMS-ppmc)
- MW
- Linear (Outlet Nox (CEMS-ppmc))
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 NH₃ 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