St. Johns River Power Park
2 x 670 MW SCR
Designed to Ensure Fuel Flexibility

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- Noel Rosha – CERAM Environmental
- Volker Rummenhohl – Tackticks, LLC.
Presentation Agenda

- Project Overview
- Fuels – Challenges
- Operating Challenges
- Catalyst Selection
- CoPilot® Catalyst Demo Test Results
- Balance of Plant Concerns
Project Overview

- Two Units – Each 670 MW (gross)
- Two 3+1 SCR Reactor Boxes per Unit (14 x 6 Frames)
- Fuels – Domestic Coal / Colombian Coal / Petcoke
- High Flue Gas Temperatures – 750 to 800° F
- Catalyst Procurement Including Co-Pilot® Catalyst Testing
- LPA Capture – Aerodynamic and Screen Removal System
- SO$_3$ Control System (Ammonia)
Fuels – Challenges

*Effects on SCR Design, Catalyst Performance and Catalyst Life*
## Fuels – Challenges and Risks

<table>
<thead>
<tr>
<th>Fuel (Blend Portion)</th>
<th>Challenges</th>
<th>Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Coal (35 to 100%)</td>
<td>• High Arsenic (up to 30 ppm)</td>
<td>• Rapid Catalyst Deactivation</td>
</tr>
<tr>
<td></td>
<td>• Low Calcium Oxide (down to 0.5%)</td>
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<tr>
<td></td>
<td>• Rapid Catalyst Deactivation</td>
<td></td>
</tr>
<tr>
<td>Colombian Coal (35 to 100%)</td>
<td>• High Silica in Fly Ash (up to 62%)</td>
<td>• Catalyst and Ductwork Erosion</td>
</tr>
<tr>
<td></td>
<td>• High Arsenic (up to 30 ppm)</td>
<td></td>
</tr>
<tr>
<td>Petroleum Coke (0 to 30%)</td>
<td>• High Sulfur (up to 6.94%)</td>
<td>• Min Operating Temps</td>
</tr>
<tr>
<td></td>
<td>• High Vanadium (&gt;2,000 ppm)</td>
<td>• Increasing SO$_3$ Emissions</td>
</tr>
<tr>
<td></td>
<td>• High Loss on Ignition (LOI)</td>
<td>• Increased Fire Potential</td>
</tr>
</tbody>
</table>

**Limited Experience With Petcoke Blends in SCR Applications**
Direct Bunkering of Fuels

- Fuels Fired Separately
- Design Considered Flue Gas “Channeling”
- Possibility for Targeted Affects

![Diagram of bunkering system with labels for Coal, Petcoke, Gas From Boiler, and SCR Reactor.](image-url)
Actual Site Photograph, July 11, 2008
Actual Plant Photographs
Actual Plant Photographs

Unit 2 ID Fan Motor
Removed off Pedestal
March 1, 2008
Actual Plant Photographs
Actual Plant Photographs
Actual Plant Photographs

Unit 2/B Catalyst Installed on Elevation
Elevation 235'-0"
February 20, 2008
Operating Challenges
Operating Challenges

- Plant Characterization Testing
  - Full Load and Low Load Operation
  - Operating Temperature
  - Temperature Stratification

- Ductwork / Reactor Design

- Control of SO₃ Emissions

- Control of LPA Carryover into SCR

- Full-time SCR Operation
Catalyst Design, Selection and CoPilot® Test Results

Ensuring Performance and Reliability Despite the Challenges
Catalyst Characterization Testing and Selection

- Predominant Objectives for Catalyst Procurement
  - Initial Low Oxidation Rate
  - Maintain Low Pluggage
  - Good Possibilities for Rejuvenation/Regeneration

- CoPilot® In-Situ Catalyst Demonstration Testing
  - Characterize SO₂ to SO₃ Conversion Rate Changes
  - Characterize Catalyst Activity Changes
  - Tested Plate and Honeycomb (2 Suppliers) Catalyst on Rotating Basis Between 3 CoPilot® Test Units

- CERAM Homogeneous Honeycomb Catalyst Selected Based on Comprehensive Technical and Commercial Evaluation
  - 0.25% Oxidation Rate (3 Layers)
  - 8.2 mm Pitch/1.0 mm Wall Thickness
CoPilot® Door Action

Flue Gas Side

- Allows for Catalyst Test Element Removal Without Unit Outage

Air Side

- Rotated Into Flue Gas
- Rotated Out of Flue Gas

Rotating Test Reactor Door Into Gas Stream
## CoPilot® Test Results

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Relative Activity, K/Ko</th>
<th>Relative SO$_2$ to SO$_3$ Conversion Rate, %</th>
<th>Hours of Operation</th>
<th>Fuels Fired (% of heat input)</th>
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<td>28</td>
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</table>
CoPilot® Test Results (cont’d)
CoPilot® Test Results (cont’d)
Catalyst Design Changes Following Procurement

- Fuel Changes Late in the Project
  - Petcoke Firing Currently Not Attractive
  - Catalyst Redesign Required for Current Fuels
  - Possibility of Petcoke Returning to Fuel Mix

![Graph showing SJRPP Reactor Potential (18,000 Hour Sizing Basis)]
Revised Catalyst Design

<table>
<thead>
<tr>
<th></th>
<th>Original Contract Basis</th>
<th>Revised Catalyst Design</th>
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</thead>
<tbody>
<tr>
<td>Fuel Blend Basis</td>
<td>70% Coal/30% Petcoke</td>
<td>100% Coal</td>
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<tr>
<td>Catalyst Pitch</td>
<td>8.2 mm</td>
<td>8.2 mm</td>
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<tr>
<td>Catalyst Volume</td>
<td>770 m³</td>
<td>770 m³</td>
</tr>
<tr>
<td>Catalyst Deactivation Basis</td>
<td>Low Deactivation (K/K₀=0.88) due to 30% petcoke blend</td>
<td>Medium-High Activation (K/K₀=0.65) due to high arsenic/low calcium oxide</td>
</tr>
<tr>
<td>Catalyst Wall Thickness</td>
<td>1.0 mm</td>
<td>1.0 mm</td>
</tr>
<tr>
<td>Initial Oxidation Rate</td>
<td>0.25% (Ammonia Off/800°F) with 3 catalyst layers installed</td>
<td>2.0% (Ammonia Off/775°F) with 3 catalyst layers installed</td>
</tr>
<tr>
<td>Guarantee NOₓ Outlet</td>
<td>0.06 lb/Mbtu (85% NOₓ reduction)</td>
<td>0.06 lb/Mbtu (85% NOₓ reduction)</td>
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<tr>
<td>Guarantee Life</td>
<td>18,000 hours</td>
<td>18,000 hours</td>
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</table>
Balance of Plant Concerns

Maintaining Plant Operational Excellence Throughout the Project
Balance of Plant Concerns

- **Limestone Addition System**
  - Increases calcium content in fly ash – mitigates Arsenic poisoning effects on catalyst
  - Limestone metered and deposited onto coal conveyor whenever domestic coal is transferred

- **SO$_3$ Control System**
  - Injection of ammonia downstream of air heater
    - Upgrade of existing system
Balance of Plant Concerns (cont’d)

- LPA Capture
  - Aerodynamic baffles at economizer outlet
  - LPA screen upstream of SCR inlet
- Air Heater Modifications
  - ABS resistant design
  - Multi-media cleaners on hot and cold end
Balance of Plant Concerns (cont’d)

- Fan Modifications
  - New ID fans
  - Upgrade of FD and PA fans
Summary
Summary

- Maintaining Fuel Flexibility Impacts All Aspects of SCR Design
- Careful Design, Coordination, and Team Support are Essential
- Plant Reliability Must Be Maintained Despite Design Challenges