*NeuStream*®-DR: Improving the effectiveness of DSI while substantially reducing the chemical cost

J.P. Feve, V.P. Business Development, *jpfeye@neustream.com*

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Current DSI Systems

- Dry sorbent injection (DSI) is a low CapEx (<20% compared to wet scrubber), high OpEx, alternative desulfurization/acid gas system
- Most current DSI installed for MATS compliance:
  - Target high acid gas removal, but low (~<50%) SO₂ removal
  - Sorbent injection: Lime, Trona, SBC (in furnace or upstream of air pre-heater)
- Mostly installed on units burning low-sulfur coal
Challenges With Current DSI Systems

- High operating cost (up to 2/3’s of injected sorbent is un-reacted)
- \( \text{SO}_2 \) removal too low for higher-sulfur coal. Achieving >90% removal no feasible with calcium and too costly with sodium
- Calcium sorbent decreases performance of ESP (resistivity)
- Impact of large flows of sorbent on ESP and baghouse when used for higher sulfur removal
- Leachability of heavy metals (As, Se) in post-DSI fly ash with sodium sorbent
NeuStream®-DR Process

- Boiler
- Flue gas w/ sulfur dioxide
- Particulate collection
- Flue gas w/o sulfur dioxide
- Stack

**Boiler**

**Sorbent Supply**
- Truck or railcar fill
- DSI system

**Sorbent Injection**
- DSI Reject Solids (fly-ash, Na₂CO₃, Na₂SO₄)

**Recycled Sorbent** (NaHCO₃)

**NeuStream®-DR process**

- Chemical supply (lime, water, NaCl)
- Solid Byproducts (CaCO₃, Na₂SO₄)
- Fly-ash (low sodium)
NeuStream®-DR:
Post DSI Fly Ash Recycling for Sorbent Recovery

- *NeuStream®-DR* enables an equivalent performance and much lower system cost alternative to wet/dry FGDs (low to moderate sulfur coals)
- *NeuStream®-DR* enables economical use of trona as a higher performance, more reliable alternative to limestone/lime DSI
- *NeuStream®-DR* recovers and recycles *wasted* sorbent and decreases DSI sorbent cost by 60%-80%
  - Recover over 90% of un-reacted trona and convert to 100% sodium bicarbonate
  - Secondary (optional) process recovers reacted trona (sodium sulfate)
- *NeuStream®-DR* provides greater design flexibility for DSI systems:
  - Higher SO₂ removal (or ability to burn higher sulfur coal) by injecting more trona at lower cost
  - Injection on cold side of pre-heater to increase reliability without sacrificing removal efficiency
NeuStream®-DR Cost Comparison: 250MW Coal Plant, Bituminous Coal

- Lower NSR required for BH vs ESP: significant savings on sorbent costs at high removal.
- NeuStream®-DR has 2 advantages: recycles unused sorbent and generates SBC (lower NSR to achieve same removal) → maximum savings, at lower CapEx, shorter construction time, and lower parasitic power.
NeuStream®-DR Cost Comparison: 250MW Coal Plant, PRB Coal

Source: 2010 IPM cost models, Sargent and Lundy for EPA
NeuStream®-DR: Potential OpEx Savings

- Typical NSR for 90% SO₂ removal with baghouse:
  3.3 (unmilled Trona) - 2.6 (milled Trona)

- For 90% SO₂ removal, 1.6 – 2.3 Na₂:SO₂ unreacted

- Typical 250MW plant: 10,000 BTU/kw-hr, 0.69 lb SO₂ / MMBTU, NSR = 3.26

<table>
<thead>
<tr>
<th></th>
<th>ton trona /hr</th>
<th>$/hr</th>
<th>$/yr*</th>
<th>$ / ton SO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Trona Injection</strong></td>
<td>6.6</td>
<td>$1,191</td>
<td>$8,349,885</td>
<td>$1,535</td>
</tr>
<tr>
<td><strong>Unreacted Trona</strong></td>
<td>4.8</td>
<td>$862</td>
<td>$6,044,702</td>
<td>$1,112</td>
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</tbody>
</table>

*80% capacity factor

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<thead>
<tr>
<th></th>
<th>Potential Savings ($/yr) @ 95% Recovery of Unreacted Trona</th>
</tr>
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<tbody>
<tr>
<td>Trona Savings</td>
<td>$6,045,000</td>
</tr>
<tr>
<td>Lime Costs</td>
<td>$805,000</td>
</tr>
<tr>
<td><strong>Total Savings</strong></td>
<td><strong>$5,240,000 (63%)</strong></td>
</tr>
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</table>
NeuStream®-DR system:
- Reduces sodium concentration, and hence leachability, of post-DSI fly ash → similar to pre-DSI fly ash
- Process independent of DSI injection and power generation process
- Simple, reliable design, no exotic chemicals
NeuStream®-DR Pilot Results

<table>
<thead>
<tr>
<th>Property</th>
<th>Lab Results</th>
<th>Batch Process Pilot Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 step</td>
<td>3 step w/ wash</td>
</tr>
<tr>
<td>Purity</td>
<td>88%</td>
<td>90%</td>
</tr>
<tr>
<td>Yield</td>
<td>82%</td>
<td>98%</td>
</tr>
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</table>

Powder low properties of recycled solids are very close to post-DSI fly ash mix (easy flow, slightly better than trona)

<table>
<thead>
<tr>
<th>mg/L</th>
<th>Raw fly ash</th>
<th>Post DSI solids, unprocessed</th>
<th>Post NeuStream®-DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromium</td>
<td>0.066</td>
<td>0.18</td>
<td>0.25</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.084</td>
<td>0.48</td>
<td>0.071</td>
</tr>
<tr>
<td>Arsenic</td>
<td>ND</td>
<td>0.21</td>
<td>0.033</td>
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</table>

Toxicity characteristic leaching procedure per SW846 6010C
Summary

- **NeuStream®-DR** process offers major advantages:
  - Up to 80% decrease in DSI OpEx with optional NaSO$_4$ converter
  - Removes most of the soluble sodium from fly ash
  - Low power usage and water consumption
  - Small footprint, simple operation

- Gives utilities added flexibility:
  - Install DSI now due to MATS Regulations
  - Add *NeuStream®-DR* later for cost control, greater SO$_X$ control, cleaner fly ash
NSG Contact Information

Eric Klein, CTO, 720-982-3813
erick@neustream.com

J.P. Feve, V.P. Business Development, 408-799-0315
jpfeve@neustream.com