Lime-based Circulation Dry Scrubber for Existing Coal-fired EGUs to Comply with the Proposed Utility MACT

Shiaw Tseng
April 7, 2011
Presentation Outline

- Graymont and Graymont Lime Operations

- U.S. EPA’s Proposed Utility MACT (NESHAP)
  - Emission Limits for Total PM, HCl & Hg for Existing Coal-fired EGUs

- Lime-based Circulation Dry Scrubber (CDS)
  - CDS Performance of AES Greenidge Station Unit #4

- Take-away
Graymont is a privately owned company, headquartered at Richmond (near Vancouver), BC, Canada. Graymont owns and operates 8 lime plants in Canada and 8 lime plants in the U.S. Graymont is a minority owner of Grupo Calidra, the largest lime producer in Mexico.

Graymont produces quick lime, hydrated lime, limestone, lime kiln dust, and lime slurry for the mining, steel, waste water, flue gas treatment, pulp & paper, chemical, and construction industries.

Graymont has a aggregates/materials division with operations in New York and Quebec areas. Graymont’s Ecowaste division operates a landfill near Vancouver, BC, Canada.
Graymont’s Products are being Used in Various Flue Gas Treatment Systems

- Dry Sorbent Injection
- Semi-wet Spray Dryer
- Circulating Dry Scrubber
- Circulating Fluidized Bed
- Wet Scrubber

Graymont ships over 550,000 tons of lime-based products annually to scrubbing applications.
# U.S. EPA’s Proposed Utility MACT (NESHAP)

Proposed emission limits for existing coal-fired and solid oil-derived fuel-fired electricity generating units (EGUs) are subcategorized by fuel and boiler types.

<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Total PM</th>
<th>HCl</th>
<th>Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing coal-fired unit designed for coal &gt; 8,300 Btu/lb</strong></td>
<td>0.03 lb/MMBtu (0.30 lb/MWh)</td>
<td>0.002 lb/MMBtu (0.020 lb/MWh)</td>
<td>1.0 lb/TBtu (0.0008 lb/GWh)</td>
</tr>
<tr>
<td><strong>Existing coal-fired unit designed for coal &lt; 8,300 Btu/lb</strong></td>
<td>0.03 lb/MMBtu (0.30 lb/MWh)</td>
<td>0.002 lb/MMBtu (0.020 lb/MWh)</td>
<td>11.0 lb/TBtu (0.20 lb/GWh) 4.0 lb/TBtu* (0.04 lb/GWh*)</td>
</tr>
<tr>
<td><strong>Existing - IGCC</strong></td>
<td>0.05 lb/MMBtu (0.30 lb/MWh)</td>
<td>0.0005 lb/MMBtu (0.0030 lb/MWh)</td>
<td>3.0 lb/TBtu (0.020 lb/GWh)</td>
</tr>
<tr>
<td><strong>Existing - Solid oil-derived</strong></td>
<td>0.20 lb/MMBtu (2.0 lb/MWh)</td>
<td>0.005 lb/MMBtu (0.080 lb/MWh)</td>
<td>0.20 lb/TBtu (0.0020 lb/GWh)</td>
</tr>
</tbody>
</table>

The proposed regulations were signed by EPA administrator Lisa Jackson on March 16, 2011, and a final rule is to be completed by November 2011. [http://www.epa.gov/airquality/powerplanttoxics/](http://www.epa.gov/airquality/powerplanttoxics/)
Generic Process Flow Diagram of a CDS System

- Boiler
- Lime-based Reagent Silo
- CDS Reactor
- Baghouse or ESP
- Stack
- Air
- Fuel
- Disposal

(Low load)
Process Characteristics of a CDS System

- High circulation rate of finely divided solids
- Lower capex (compared with wet scrubbing systems)
- Multi-pollutant controls (SO$_2$, SO$_3$, HCl, HF, Hg, trace metals)
- Fuel flexibility
- Small footprint, simple process, easy to maintain
- Low water consumption
- Dry byproduct (i.e., no waste sludge to handle)
CDS at AES Greenidge Station Unit #4

AES Greenidge Station Unit #4 (Boiler #6)
- Dresden, NY
- 107 MW (net)
- Combustion Engineering T-fired boiler
- Boiler commissioned in 1953
- 780,000 lb/h steam @1465 psig and 1005°F
- Eastern bituminous coal w/2.5% S

CDS vendor: Babcock Power Environmental
- CDS startup: Dec 2006
- Onsite hydrator

The multi-pollutant control project at AES Greenidge received funding from the U.S. Department of Energy under Cooperative Agreement DE-FC26-06NT41426

### CDS Performance at AES Greenidge Station Unit #4

**Fuel:** 2.5-3.0% sulfur eastern U.S. bituminous coal

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Target</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{NO}_x ) emissions</td>
<td>( \leq 0.10 \text{ lb/mmBtu} )</td>
<td>( 0.10 \text{ lb/mmBtu} ) (Stack CEM, 3/28/07)</td>
</tr>
<tr>
<td>( \text{SO}_2 ) removal</td>
<td>( \geq 95% )</td>
<td>96% (Stack CEM, 3/29/07)</td>
</tr>
<tr>
<td>Hg removal</td>
<td>( \geq 90% )</td>
<td>( \geq 95% ) (Ontario Hydro, 3/28/07)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( \geq 94% ) (Ontario Hydro, 3/30/07)</td>
</tr>
<tr>
<td>( \text{SO}_3 ) removal</td>
<td>( \geq 95% )</td>
<td>97% (Controlled Condensation, 5/2/07)</td>
</tr>
<tr>
<td>HCl removal</td>
<td>( \geq 95% )</td>
<td>97% (EPA Method 26, 5/4/07)</td>
</tr>
</tbody>
</table>

AES Greenidge Station Unit #4

Ca/S molar Ratio = 1.65
During Performance Tests
(CONSOL Energy)

0.15 lb/MMBtu
Emission Tests Conducted at AES Greenidge Station Unit #4

- 2004.11.17- Baseline Tests

In the following tests, the loadings and emissions of PM, SO$_3$, HCl, HF, and Hg (with speciation) were taken.

- 2007.3.28-29 & 2007.5.4 – Performance Guarantee Tests
- 2007.3.30 – Carbon Injection Tests
- 2007.10.2-3 – High S Coal Tests
- 2007.10.5 – High S Coal with Carbon Injection Tests
- 2007.10.8-10 – Turbosorp™ Parametric Tests

- 2008.3.10-13 – Biomass Co-firing Tests
- 2008.5.19-22 – Low Load Tests
- 2008.06.10-13 – Follow-up Tests
# Results of Performance Guarantee Tests Conducted at AES Greenidge Station Unit #4

<table>
<thead>
<tr>
<th>Location</th>
<th>AHO-1</th>
<th>Stack-1</th>
<th>AHO-2</th>
<th>Stack-2</th>
<th>AHO-3</th>
<th>Stack-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Heat Input (MMBtu/hr)</strong> *</td>
<td>1,031</td>
<td>1,034</td>
<td>1,082</td>
<td>1,052</td>
<td>1,055</td>
<td>1,035</td>
</tr>
<tr>
<td><strong>PM (lb/MMBtu)</strong> **</td>
<td>5.212</td>
<td>0.00012</td>
<td>4.628</td>
<td>0</td>
<td>4.945</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total Hg (lb/TBtu)</strong></td>
<td>7.29</td>
<td>&lt;0.35</td>
<td>8.4</td>
<td>&lt;0.37</td>
<td>7.96</td>
<td>&lt;0.40</td>
</tr>
</tbody>
</table>

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<tr>
<th>Location</th>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Heat Input (MMBtu/hr)</strong> *</td>
<td>1,068.9</td>
<td>959.5</td>
<td>1,035.1</td>
<td>1,014.0</td>
<td>1,052.3</td>
<td>1,006.3</td>
</tr>
<tr>
<td><strong>PM (lb/MMBtu)</strong> **</td>
<td>5.108</td>
<td>0.00074</td>
<td>4.818</td>
<td>0.00047</td>
<td>5.071</td>
<td>0.00056</td>
</tr>
<tr>
<td><strong>HCl (lb/MMBtu)</strong> ***</td>
<td>0.0386</td>
<td>0.0029</td>
<td>0.0408</td>
<td>0.0012</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HF (lb/MMBtu)</strong></td>
<td>&lt;1.96E-04</td>
<td>&lt;1.15E-04</td>
<td>&lt;2.03E-04</td>
<td>&lt;1.38E-04</td>
<td>&lt;2.00E-04</td>
<td>&lt;1.19E-04</td>
</tr>
</tbody>
</table>

* The calculated Heat Input was F-factor based.

** The PM data were the "front-half" catch of EPA Method 5 sampling train.

*** The Tests were disqualified due to impinger backflushing.

The original data were taken from “Greenidge Project Final Report” dated May 27, 2009.
Results of **Performance Guarantee Tests** Conducted at AES Greenidge Station Unit #4

<table>
<thead>
<tr>
<th></th>
<th>Total PM (lb/MMBtu)</th>
<th>HCl (lb/MMBtu)</th>
<th>Hg (lb/TBtu)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility MACT Proposed by U.S. EPA</td>
<td>0.03</td>
<td>0.002</td>
<td>1.0</td>
<td>Mar. 16, 2011</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>PM (lb/MMBtu)</th>
<th>SO₃ (lb/MMBtu)</th>
<th>HCl (lb/MMBtu)</th>
<th>Hg (lb/TBtu)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>AES Greenidge Performance Tests</td>
<td>0.00012</td>
<td></td>
<td>&lt;0.37</td>
<td>Mar. 28, 2007</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.00059</td>
<td>0.0021</td>
<td></td>
<td>Mar. 29, 2007</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0024</td>
<td></td>
<td>0.0013</td>
<td>May 4, 2007</td>
<td></td>
</tr>
</tbody>
</table>

The performance test data summarized in the above table were the averages of two or three tests.

Results obtained from performance guarantee tests show that:
1. The emission of **Total PM** (non-condensable & condensable) was lower than the proposed utility MACT limit
2. The emission of **HCl** met or was lower than the proposed utility MACT limit
3. The emission of **Hg** was lower than the proposed utility MACT limit
Take-away

Data obtained from the “performance guarantee tests” conducted at AES Greenidge Station Unit #4 show that the emissions from an existing bituminous coal-fired EGU with a well designed and operated circulation dry scrubber with baghouse can meet/exceed the Utility MACT limits proposed by U.S. EPA on March 16, 2011.