Implementation of Clean Air Act Requirements for Advanced Coal Technologies

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Topics

• Bob Wayland has discussed overall CAA:
  – Rules and how they apply to utility sector
  – Timeline
  – Regulatory process
  – Projected emissions and retrofits to comply with CAIR, CAMR, CAVR
  – BACT and LAER

• Now let’s see how ACTs that being planned are going to comply with these rules:
  – How emission control systems for PC and IGCC are different
  – Focus on New Source Performance Standards
  – How emission limits compare
Applicable Air Regulations

- National Ambient Air Quality Standards (NAAQS)
- New Source Review (NSR) requirements, including Prevention of Significant Deterioration (PSD) and Non-Attainment NSR; and BACT/LAER
- New Source Performance Standards (NSPS)
- National Emission Standards for Hazardous Air Pollutants (NESHAPs) including proposed Utility MACT and Combustion Turbine MACT rules
- Federal Acid Rain Program (Title IV)
- Operating permit (Title V)
- Clean Air Interstate Rule (CAIR)
- Clean Air Mercury Rule (CAMR)

Technology Comparison

<table>
<thead>
<tr>
<th></th>
<th>PC</th>
<th>IGCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedstock</td>
<td>-</td>
<td>Coal</td>
</tr>
<tr>
<td>Fuel</td>
<td>Coal</td>
<td>Syngas</td>
</tr>
<tr>
<td>Combustion</td>
<td>Coal in boiler</td>
<td>Syngas in gas turbine</td>
</tr>
<tr>
<td>Emission Control</td>
<td>Post-combustion clean-up of large volume of exhaust gas</td>
<td>Pre-combustion clean-up of small volume of syngas</td>
</tr>
</tbody>
</table>
Comparison of Air Emission Controls: PC and IGCC

<table>
<thead>
<tr>
<th></th>
<th>SO₂</th>
<th>NOₓ</th>
<th>PM</th>
<th>Mercury</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PC</strong></td>
<td>Limestone-based FGD system</td>
<td>Low-NOₓ burners and SCR</td>
<td>ESP or baghouse</td>
<td>Inject activated carbon into flue gas</td>
</tr>
<tr>
<td><strong>IGCC</strong></td>
<td>Amine system removes H₂S from syngas</td>
<td>Syngas saturation and N₂ diluent</td>
<td>Wet scrubber, high temperature cyclone, ceramic filter</td>
<td>Pre-sulfided activated carbon bed in syngas stream</td>
</tr>
</tbody>
</table>

IGCC - a Different Environment Than PC

- Gasification occurs in a reducing atmosphere
  - sulfur compounds are liberated as H₂S and COS
  - removed by refinery industry technologies to levels ≥99%
- Low levels of H₂S in the syngas are burned in the gas turbine and become SO₂ in exhaust
- NOₓ is controlled by injecting N₂ at ~1:1 ratio with syngas, as well as saturating the syngas stream with water or steam (cools the flame)
**New NSPS**

<table>
<thead>
<tr>
<th>Emission</th>
<th>NSPS on Input Basis for IGCC (estimated)</th>
<th>NSPS on Input Basis for PC (estimated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>1.0 lb/MWh*</td>
<td>0.132 lb/MBtu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.11 lb/MBtu</td>
</tr>
<tr>
<td>SO₂</td>
<td>1.4 lb/MWh* and minimum 95% removal</td>
<td>0.185 lb/MBtu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.155 lb/MBtu</td>
</tr>
<tr>
<td>PM</td>
<td>Lesser of 0.14 lb/MWh* or 0.015 lb/MBtu</td>
<td>0.015 lb/MBtu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.015 lb/MBtu</td>
</tr>
<tr>
<td>Mercury</td>
<td>20 x 10⁻⁶ lb/MWh* (bituminous)</td>
<td>2.6 lb/TTu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2 lb/TTu</td>
</tr>
</tbody>
</table>

*output-based standards are on a gross generation basis, so gross heat rate is used to calculate estimated input-based limit*

**New Source Performance Standards**

- NSPS for Electric Utility Steam Generating Units (Subpart Da), February, 2006:
  - Applies to IGCC combustion turbines that burn ≥ 75% “synthetic coal gas”
  - When burning <75% syngas (12-month rolling average), Subpart KKKK applies
    - This could be a problem during initial start-up
    - Meeting the NSPS for NOx may not be possible when burning natural gas in diffusion burners designed for syngas
  - Industry requested modification to regulations
New Source Performance Standards

- EPA proposed changes in February 2007
- IGCC is only covered by subpart Da, if:
  - “The combined cycle gas turbine is designed and intended to burn fuels containing 50 percent (by heat input) or more solid-derived fuel not meeting the definition of natural gas on a 12-month rolling average basis; and
  - The combined cycle gas turbine commenced construction, modification, or reconstruction after February 28, 2005.”

New Source Performance Standards

- Coal-fired electric utility steam generating unit means an electric utility steam generating unit that burns coal, coal refuse, or a synthetic gas derived from coal either exclusively, in any combination together, or in any combination with other fuels in any amount.
New Source Performance Standards

• Integrated gasification combined cycle electric utility steam generating unit or IGCC means a coal-fired electric utility steam generating unit that burns a synthetic gas derived from coal in a combined-cycle gas turbine. No coal is directly burned in the unit during operation.

Air Permitting Requirements

• IGCC and PC plants are similar
  – Fugitive dust controls
    • Coal delivery, unloading and handling
  – Cooling towers
    • But IGCC cooling towers would have lower duty since only 40% of plant output is from steam turbine generator
  – Air dispersion modeling
  – BACT analysis for emission controls
Air Permitting: IGCC

• Unique emission points depend on technology provider
  – Flare
  – Start-up burner
  – Gasifier pre-heat burner
  – Sulfur Recovery Unit tail gas incinerator
  – Sulfuric Acid Plant stack
  – Tank vents
  – Air Separation Unit cooling tower

Air Permitting: IGCC

• For air permit application:
  – Inventory of emission points has to be developed early in the engineering process
  – Emission limits in lb/hr are easier for measurement and compliance than ppm or lb/MMBtu
  – Startup, shutdown and emergency emissions must be calculated – and can be substantial
  – Emissions from flare are critical
    • Raw syngas
    • Clean syngas
    • Duration
    • Number of flare events/year
What About SCR for IGCC?

- Technical issues
  - The fuel is syngas, not natural gas as in NGCC
  - Ammonium sulfate/bisulfate deposits in the HRSG, causing corrosion and plugging, requiring more downtime for washdowns
  - Possible poisoning of SCR catalyst from syngas
  - No coal-based IGCC system in the world uses SCR

- Economic Issues
  - No commercial guarantees yet with syngas
  - SCR would require deeper sulfur removal to reduce sulfate formation to low levels
    - Selexol
    - Higher capital costs

SCR in a PC Plant
SCR: PC vs IGCC

• SCR in a PC plant
  – Air pre-heater baskets:
    • have large openings due to the fly ash in the exhaust gas stream
    • are designed for removal, replacement and cleaning
  – Particulates are removed downstream in the ESP, FGD system, or baghouse

SCR: PC vs IGCC

• SCR in an IGCC plant
  – heat transfer occurs in the HRSG
    • on fixed finned tubing with small clearances
    • designed for exhaust gas from natural gas combustion – no sulfates/bisulfates
    • sulfate/bisulfate deposition would be a problem on finned tubing
    • finned tubing is not designed for removal, replacement or easy cleaning
Why SCR?

• But more IGCC plants are being proposed with SCR than without SCR
• Reasons:
  – As BACT
  – As Innovative Control Technology to reduce emissions beyond diluent injection
  – As a trial/experiment, with emission limits proposed only for natural gas use
  – To evaluate SCR as part of DOE demonstration program with a syngas-fired combined cycle unit
  – To minimize NOx emissions in order to reduce NOx emission allowance costs

NOx BACT

• EPA has addressed this issue
• Report notes technical problems with using SCR w/IGCC
• Looked at SCR w/Selexol for deep sulfur removal
• EPA concluded that:
  – even w/Selexol, problems are not solved
  – additional cost and reduced output are negative impacts to IGCC
  – BACT will continue to be a case-by-case issue
Mercury Removal: PC

- Inject activated carbon in flue gas stream
- Mercury adsorbed onto carbon particle
- Particles removed in ESP or baghouse

Mercury Removal: IGCC

- Pre-sulfided carbon beds in syngas stream
- Forms a mercury-sulfur complex
- Spent carbon disposed of in drums once/year
- Most IGCC plants plan to use this technology

Source: Eastman Chemical
**NOx and SO₂ Emissions**

- NOx emission rates not very different for proposed PC and IGCC units

- IGCC units being proposed with much lower SO₂ emission rates
  – due to ability to remove higher percentages of H₂S vs SO₂

- Mercury emission rates about the same for PC and IGCC

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**Air Emission Comparisons - NOx**

![Graph showing NOx emissions for various units]
Air Emission Comparisons – SO₂

- Orlando Gasification IGCC - PRB
- Seminole Unit #3 SCPC - Bit. Coal/Pet Coke
- Taylor Energy Center SCPC- Bit Coal/Pet Coke
- Peabody Thoroughbred SCPC - Bit Coal
- Excelior Energy Meauba IGCC - PRB
- AEP IGCC - Bit. Coal
- Duke Edwardsport IGCC - Bit. Coal
- FPL Glades USC - Bit. Coal/Pet Coke
- TXU SCPC - PRB
- ERORA IGCC w/SCR - Bit. Coal
- Tondu Nuences IGCC - Pet Coke
- Energy Northwest IGCC - PRB or Pet Coke