Implementation of Clean Air Act Requirements for Advanced Coal Technologies

Steve Jenkins

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Tampa, FL

Advanced Coal Technology Work Group
March 6, 2007

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

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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)

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Technology Comparison

	PC	IGCC
Feedstock	-	Coal
Fuel	Coal	Syngas
Combustion	Coal in boiler	Syngas in gas turbine
Emission Control	Post-combustion clean-up of large volume of exhaust gas	Pre-combustion clean-up of small volume of syngas

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Comparison of Air Emission Controls: PC and IGCC

	SO_2	NOx	PM	Mercury
PC	Limestone-based FGD system	Low-NOx burners and SCR	ESP or baghouse	Inject activated carbon into flue gas
IGCC	Amine system removes H_2S from syngas	Syngas saturation and N_2 diluent	Wet scrubber, high temperature cyclone, ceramic filter	Pre-sulfided activated carbon bed in syngas stream

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IGCC - a Different Environment Than PC

- Gasification occurs in a reducing atmosphere
  - sulfur compounds are liberated as H_2S and COS
  - removed by refinery industry technologies to levels ≥99%
- Low levels of H_2S in the syngas are burned in the gas turbine and become SO_2 in exhaust
- NOx is controlled by injecting N_2 at ~1:1 ratio with syngas, as well as saturating the syngas stream with water or steam (cools the flame)

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New NSPS

Emission	NSPS	NSPS on Input Basis for IGCC (estimated)	NSPS on Input Basis for PC (estimated)
NOx	1.0 lb/MWh*	0.132 lb/MMBtu	0.11 lb/MMBtu
SO_2	1.4 lb/MWh* and minimum 95% removal	0.185 lb/MMBtu	0.155 lb/MMBtu
PM	Lesser of 0.14 lb/MWh* or 0.015 lb/MMBtu	0.015 lb/MMBtu	0.015 lb/MMBtu
Mercury	20 x 10^{-6} lb/MWh* (bituminous)	2.6 lb/TBtu	2.2 lb/TBtu

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

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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

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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."

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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.

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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.

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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

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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

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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

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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

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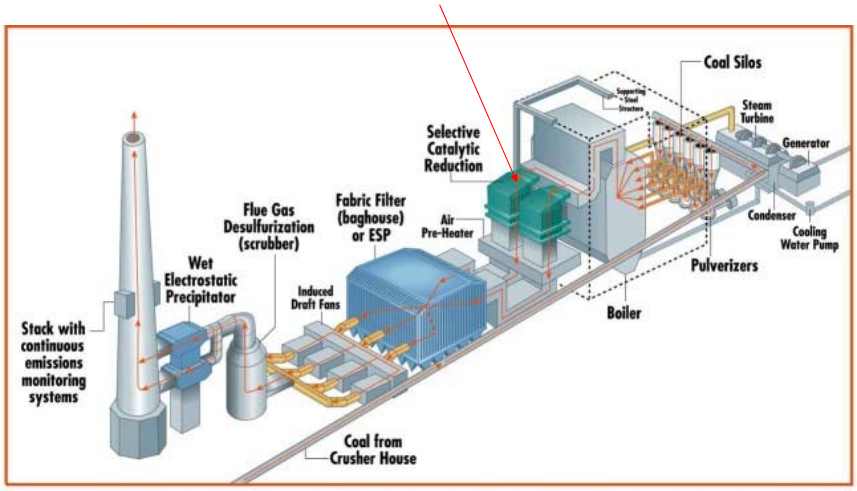
SCR in a PC Plant



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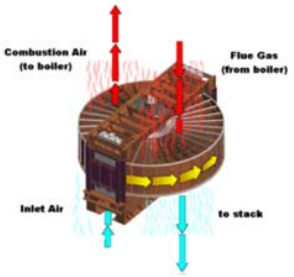
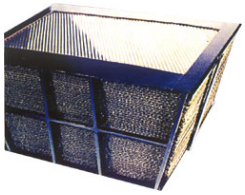
SCR: PC vs IGCC

- 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





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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

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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

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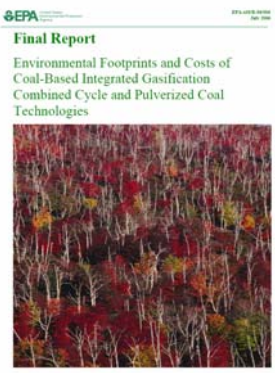
NOx BACT

- 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



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Mercury Removal: PC

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

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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

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NOx and SO_2 Emissions

- NOx emission rates not very different for proposed PC and IGCC units
- IGCC units being proposed with much lower SO_2 emission rates
  - due to ability to remove higher percentages of H_2S vs SO_2
- Mercury emission rates about the same for PC and IGCC

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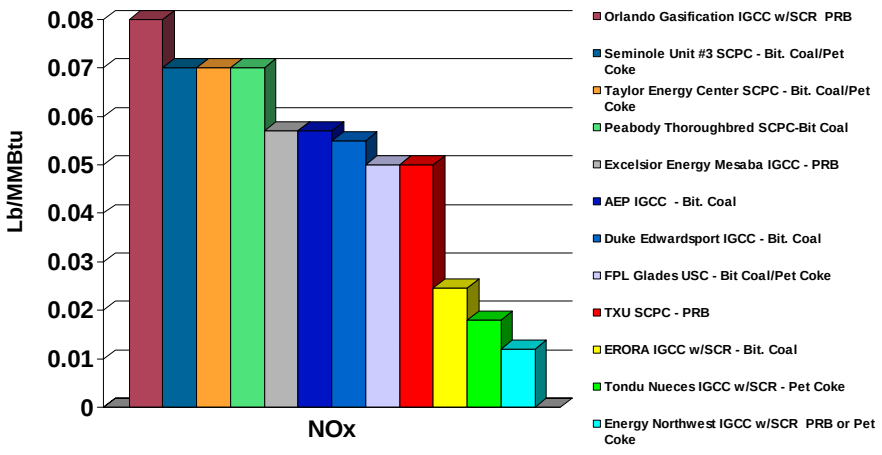
Air Emission Comparisons - NOx



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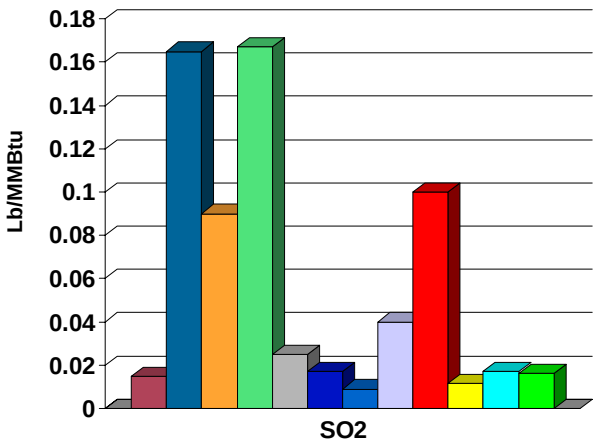
Air Emission Comparisons – SO_2



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