Ashworth Gasifier - Combustor Multi-Pollutant Control for Power Plants

Presented by:

ClearStack Power, LLC
WHY DISCUSS CLEAN COAL TECHNOLOGIES IN CURRENT REGULATORY ENVIRONMENT?

EPA Requirements Triggering Large Environmental Retrofit Investments for Continued Coal Use in Existing Coal-Fired Powerplants
- MATS- Triggering Extensive Coal Unit Retirements
- BART- Triggering Western Coal Unit Retirements- Battles over NOx Limitations
- 316 B Cooling Water Intake Structures
- GHG Emission Limitations for Existing Coal Plants- Expected June 2014

Tightening Future Rules for New Coal Capacity
- EPA Proposed NSPS Limitation for Greenhouse Gases from Power Industry

ClearStack’s Ashworth Gasifier - Combustor

AG-C Features:

- 3-stage pulverized coal oxidation
- SO$_2$ reduction: 90+% 
- NO$_X$ emissions: 0.095 lb/10$^6$ Btu
- CO emissions: < 10 ppmd @ 3% O$_2$
- Hg capture in ash: 90 to 100%
- Other air metal toxics capture: 80 to 100%
- HCL, HF reductions
4 MWe AG-C Retrofit @ Lincoln

Lincoln Development Center - Unit #2
ClearStack’s Ashworth Gasifier - Combustor

- Air entrained gasifier design able to be retrofitted onto existing coal fired boilers. No oxygen plant required.

- Effective SO$_2$, NO$_X$, Mercury (and other Air Metal Toxics), Cl and F control applied to any boiler type without post-combustion controls

- Provides greater fuel feedstock flexibility - able to handle waste coals, higher biomass blends, higher sulfur coals, etc.

- Produces salable inert dry slag and fly ash - no scrubber sludge byproduct

- Reduces fly ash particulate loadings - able to reduce particulate emissions

- Small overall equipment footprint

- Low power requirement, higher efficiency than backend technologies
NO\textsubscript{x} and CO Emissions

Alstom Analysis for 85 MWe T-Fired Boiler Firing Bituminous Coal

NO\textsubscript{x} = 86 ppm
0.095 lb/10\textsuperscript{6} Btu

CO = 7-8 ppm
Sulfur Capture Chemistry

Sulfur Capture as CaSO₄

Equilibrium Coefficient, \( K_p \)

Temperature, \( ^\circ F \)

Sulfur Capture as CaS

\[
\text{CaO} + \text{H}_2\text{S} = \text{CaS} + \text{H}_2\text{O}
\]

Equilibrium Coefficient, \( K_p \)

Temperature, \( ^\circ F \)

Oxidizing

Strongly Reducing
Mercury Capture

Mercury capture in strong reducing alkaline molten slag bath is the result of:

$$\text{Ca}^\circ + \text{Hg}^\circ = \text{CaHg} \text{ (metal solution)}$$

Unique to Ashworth Gasifier

Paul Chu relayed that the coal gasifiers that EPRI tested showed no mercury capture.

_They don’t fire into a molten slag bath!_
Slag and Fly Ash

- Slag for asphalt shingles/road bed
- Fly Ash for cement (stronger and longer lasting)

Biomass Co-firing Capable

- Co-fire 10 - 15% biomass w/coal
- Capture corrosive alkalis (Na, K) in gasifier slag
AG-C Test Results @ Lincoln

$\text{NO}_x$ : Low as 0.095 lb/$10^6$ Btu

$\text{SO}_2$ : 1.70 lb/$10^6$ Btu w/80% minus 200 mesh limestone

$\text{CO}$ : 15 - 30 ppmv @3% $\text{O}_2$ dry

Hg : 93 - 100 % removal \( \text{Leachate tests: Slag = 0 mg/l, Fly Ash = 0 mg/l} \)

$\text{HCl/HF}$: 13% Cl & 26% F Reduction

Carbon Conversion: 99 wt%

Other Air Toxic Reductions:

80 - 100% capture of Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Ag, Tl, V, Zn

No Leaching:

Leachate tests on slag and fly ash showed that Ag, As, Ba, Cd, Pb, and Se (only metals regulated besides Hg) were all well below the EPA regulatory limits just as Hg was.
ClearStack Offers Low Cost Solution

Ashworth Gasifier - Combustor™

- Retrofit to Any Coal-fired Power Plant

  Pulverized coal-fired units low retrofit cost
  Ideal for existing 200 MWe units and less

  Could become BACT for new coal-fired units

- Lower Cost than SCR + Wet Scrubber and less CO₂ emitted
CO₂ Effect

Added Tons CO₂ with SCR-WS Retrofit Compared to AG-C Retrofit
(Auxillary Energy Effect)
170 MWe AG-C Compared to SCR-WS

**Ashworth Gasifier - Combustor**

Retrofit Cost (T-Fired 170 Mwe): $25.6 Million

Operating Cost: $5.5 Million/yr

**Selective Catalytic Reduction w/Wet Scrubber**

Retrofit Cost (T-Fired 170 Mwe): $67.3 Million

Operating Cost: $15.3 Million/yr
Comparison to Post-Combustion Costs

*Actual costs will depend upon site specific layout and equipment condition
Sterling plans to retrofit #6 boiler (12.65 MWe Unit), with the Ashworth Gasifier-Combustor. The unit would then comply with all environmental regulations.
Crawfordsville Boiler #6

#6 B&W Boiler w/Detroit Stoker RotoGrate - Installed in 1965
Crawfordsville Boiler #6 Retrofit

Simplified PFD of Ashworth Gasifier-Combustor for Boiler #6
## Crawfordsville Boiler #6
### Capital Cost Estimate

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<th>Description</th>
<th>Cost</th>
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<td>Process Engineering</td>
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<td>Detail Engineering</td>
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<td>Contingency @25%</td>
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<td><strong>Total</strong></td>
<td><strong>$6,450,000</strong></td>
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Crawfordsville Projected Emissions

SO₂ Reduction (w/fine limestone) : 90 to 100%
HCl/HF Reduction (w/fine limestone) : 90 to 100%
NOₓ Emissions (3 stage oxidation) : 0.095 lb/MMBtu
Mercury Reduction (slag capture) : 95 to 100%
Air Metal Toxics Reduction (slag capture) : 80 to 100%
Leaching (Hg, Ag, As, Ba, Cd, Pb, and Se) : below EPA limits
Particulate Reduction (ash capture in gasifier) : 80%
CO Emissions (Alstom analysis) : 7 to 8 ppm
Conclusions

The ClearStack Ashworth Gasifier-Combustor can be retrofitted onto existing coal boilers to reduce the air emissions (NO$_x$, SO$_2$, Hg, other air toxics and halides) to meet MATS and BART standards without post-combustion controls.

It greatly expands coal unit fuel flexibility and can handle waste coal, high ash coal and biomass.

By avoiding post-combustion controls and an oxygen plant, the atmospheric air blown Ashworth Gasifier-Combustor will be more efficient than a conventional Integrated Gasifier Combined Cycle (IGCC) power plant or a Conventional PC boiler with Post Combustion controls.

Requires less space and is less expensive to install and operate than conventional post-combustion control measures.
Any Questions ??

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