Comparison of IGCC and Pulverized Coal Technologies in a BACT Analysis

Workshop on Gasification Technologies
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Clean Air Task Force
• Clean Air Task Force (CATF) in Brief
• The Changing Context for IGCC in “best available control technology” (BACT) review
• CATF Illustration of BACT Cost Comparison
• Sensitivity Analysis for CATF Illustration
• Key Results
Clean Air Task Force in Brief

• The Clean Air Task Force (CATF)
  • National non-profit environmental organization founded in 1996
  • Major focus has been on controlling power plant air pollution
    – Legal advocacy
    – Scientific research
    – Public education
  • Related projects to support cleaner technology, including support for IGCC projects such as
    – Duke Energy Edwardsport, Indiana IGCC
    – AEP Mason County, WV IGCC
    – Tenaska Taylorville, IL IGCC
Some IGCC Are Moving Forward

- **Recent examples**
  - Tenaska IGCC, Taylorville, Illinois
    - Air permit issued June, 2007
    - EAB order supporting air permit issued January, 2008
  - Duke Energy IGCC, Edwardsport, Indiana
    - IURC approval November, 2007
    - Air Permit issued January, 2008
    - Breaking ground soon
  - AEP IGCC, Mason County, West Virginia
    - WV PSC approval March, 2008
    - VA corporation commission action expected in April, 2008
    - WV air permit expected soon
Emissions Profile for New Coal

Air Emissions of Recently Approved Plants

Emissions (lb/MMBtu coal)

PSGC SCPC (IL)
AEP IGCC (WV)
Duke IGCC (IN)
Tenaska IGCC (IL)

SO2
NOx
PM
CO
VOC

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Policy Context for Coal is Changing

• CO2 emission restrictions, in some form, are highly likely
  • Federal legislation (e.g., Lieberman-Warner)
  • State and regional actions (e.g., RGGI)
  • Frequent new developments (e.g., Waxman-Markey this week)
  • Legal challenges (e.g., Mass v. EPA, etc.)

• A new administration will be coming to Washington
  • Likely to change the CO2 discussion
    – Major climate bills sponsored by McCain, Clinton, and Obama
  • Could change historical practices with respect to IGCC and BACT for criteria pollutants

• In any event, the energy, coal, IGCC, and BACT future is likely to be quite different from the recent past
A (Short) History of IGCC in BACT Analyses

• Some have argued that IGCC should not be part of a coal-fueled power plant BACT analysis because to do so impermissibly “redefines” the source proposed by a permit applicant
• Others have argued that IGCC must be part of the BACT analysis because evaluation of cleaner “production processes”, “clean fuels”, and other approaches is required by the Clean Air Act
• Ultimately the disagreement concerns the proper scope of BACT with respect to a facility’s fundamental nature
• Different regulatory agencies (e.g., NM, MI, IL, US EPA) and different actors have offered different perspectives
Given the Changing Terrain, What Does a Fresh Look at IGCC in BACT Reveal?

• CATF has developed an illustrative comparison based on an EPA method and EPA data

• The method: 5-Step “Top-Down” BACT per EPA’s 1990 New Source Review Manual (“NSRM”)
  • A method is described for consideration of production processes for “identical or similar products from identical or similar raw materials or fuels” (NSRM at B.10)
  • NSRM available at http://www.epa.gov/ttn/nsr/gen/wkshpman.pdf

• The data: EPA report from 2006

• Even with guidance and data, challenges remain
  • Each process of producing electricity from coal is itself a control technology, and overall costs of production and emission reduction must be properly allocated to environmental benefits
4 Study Plants in CATF Illustration

• CATF illustration built on EPA “Footprints Report” data
  • EPA 2006 study; emissions based on recent permits; performance and cost based on published studies
  • EPA’s 4thQ 2004 capital costs adjusted +33%

• CATF developed 4 study plants based on EPA’s data
  • Study plants are 500 MW net output with bituminous coal feed
  • “PC-1”, direct per EPA data, w/SCPC with SCR, wet FGD, and FF
  • “IGCC-0”, direct per EPA data, O2-blown IGCC with MDEA for AGR and Claus SRU, syngas dilution for NOx control
  • “PC-NSPS”, adapted from “PC-1” by CATF, with control only as necessary to meet NSPS Subpart Da levels
  • “IGCC-1”, adapted from “IGCC-0” by CATF, but with Selexol for syngas sulfur removal, and SCR for NOx control
  • Heat rates of PC and IGCC units have not been adjusted
Details of the CATF Illustration

• In the CATF reference case comparison
  • SO2 allowances are included at $500/ton; NOx at $2500/ton
  • CO2 allowances are included at $5/ton
  • Fuel costs are included at $1.80/MMBtu
  • A consistent cost of capital is used (10% annual CRF)
  • Total annual cost (“TAC”) is cost of producing electricity from each plant, calculated using an equivalent uniform annual cost (EUAC) method, considering capital cost repayment, fixed and variable O&M, fuel costs, and costs of emission allowances
  • TAC is 100% allocated to criteria pollutant emissions; for simplicity allocation to other effluents/impacts is ignored
  • Costs and emissions are based on 85% capacity factor
# CATF Study Plant Matrix for Reference Case

<table>
<thead>
<tr>
<th>Output/Assumption</th>
<th>&quot;PC-NSPS&quot;</th>
<th>&quot;PC-1&quot;</th>
<th>&quot;IGCC-0&quot;</th>
<th>&quot;IGCC-1&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output, Net, MWe</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Heat Rate, HHV, Btu/kWh</td>
<td>8900</td>
<td>8900</td>
<td>8167</td>
<td>8167</td>
</tr>
<tr>
<td>Total heat input rate, MMBtu/hr</td>
<td>4450</td>
<td>4450</td>
<td>4083.5</td>
<td>4083.5</td>
</tr>
<tr>
<td>SO2, lb/MMBtu</td>
<td>0.170</td>
<td>0.086</td>
<td>0.043</td>
<td>0.021</td>
</tr>
<tr>
<td>NOx, lb/MMBtu</td>
<td>0.121</td>
<td>0.060</td>
<td>0.049</td>
<td>0.010</td>
</tr>
<tr>
<td>PM (Filterable), lb/MMBtu</td>
<td>0.017</td>
<td>0.012</td>
<td>0.007</td>
<td>0.007</td>
</tr>
<tr>
<td>CO, lb/MMBtu</td>
<td>0.100</td>
<td>0.100</td>
<td>0.030</td>
<td>0.030</td>
</tr>
<tr>
<td>VOC, lb/MMBtu</td>
<td>0.0024</td>
<td>0.0024</td>
<td>0.0017</td>
<td>0.0017</td>
</tr>
<tr>
<td>Total Criteria Emissions, ton/yr</td>
<td>6803</td>
<td>4316</td>
<td>1986</td>
<td>1061</td>
</tr>
<tr>
<td>CO2, ton/yr</td>
<td>3347349</td>
<td>3347349</td>
<td>3025771</td>
<td>3025771</td>
</tr>
<tr>
<td>Total Capital Requirement, $/kW (net)</td>
<td>1739.65</td>
<td>1902.74</td>
<td>2221.10</td>
<td>2294.25</td>
</tr>
<tr>
<td>Capital Recovery Factor, %/yr</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Annual Capital Charge, M$/yr</td>
<td>86.982</td>
<td>95.137</td>
<td>111.055</td>
<td>114.713</td>
</tr>
<tr>
<td>Total Annual Non-Fuel O &amp;M, M$/yr</td>
<td>25.822</td>
<td>29.000</td>
<td>27.310</td>
<td>30.990</td>
</tr>
<tr>
<td>Fuel Cost, M$/yr</td>
<td>59.642</td>
<td>59.642</td>
<td>54.730</td>
<td>54.730</td>
</tr>
<tr>
<td>Sub-Total, Annual Production Costs, M$/yr</td>
<td>172.447</td>
<td>183.780</td>
<td>193.095</td>
<td>200.433</td>
</tr>
<tr>
<td>CO2 Allowance Cost, M$/yr</td>
<td>16.737</td>
<td>16.737</td>
<td>15.129</td>
<td>15.129</td>
</tr>
<tr>
<td>Sub-Total, Annual Allowance Costs, M$/yr</td>
<td>23.170</td>
<td>19.932</td>
<td>17.319</td>
<td>15.660</td>
</tr>
<tr>
<td>Total Annual Cost, M$/yr</td>
<td>195.617</td>
<td>203.712</td>
<td>210.414</td>
<td>216.092</td>
</tr>
</tbody>
</table>
CATF Illustration - Plant Emissions Levels

Study Cases Emissions

Emissions (lb/MWh net basis)

"PC-NSPS" | "PC-1" | "IGCC-0" | "IGCC-1"

VOC | CO | PM | NOx | SO2

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CATF Illustration – Cost of Electricity

Study Cases Cost Breakdown

Total Annual Cost ($/MWh)

- CO2 Allowances
- Criteria Allowances
- Fuel
- Non-Fuel O&M
- Capital Charge

"PC-0"  "PC-NSPS"  "PC-1"  "IGCC-0"  "IGCC-1"
“Cost effectiveness” is the cost of control divided by the quantity of pollution removed, expressed in $/ton
Numerically high CE (high $/ton) is less desirable
In this comparison:
- Cost of control is TAC for the study plant less TAC for the baseline plant (the NSPS-level PC plant)
- Quantity of pollutant removed is total emissions from the baseline plant (SO2+NOx+PM+CO+VOC) less total emissions from the study plant
- Both average and incremental cost effectiveness are calculated; the difference is the choice of baseline

Total costs also can be apportioned to individual pollutants based on the baseline plant emissions profile
CE = $y/\Delta x$ between plants [$/\text{ton}]
= $3,255/\text{ton}$ (PC-1; in red)
= $3,072/\text{ton}$ (IGCC-0; in green)
Cost effectiveness of PC-1, IGCC-0, and IGCC-1, for all criteria pollutants combined, is indicated below

<table>
<thead>
<tr>
<th>Cost Effectiveness (CE)</th>
<th>PC-1</th>
<th>IGCC-0</th>
<th>IGCC-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average CE v. PC-NSPS Baseline</td>
<td>$3,255/ton</td>
<td>$3,072/ton</td>
<td>$3,566/ton</td>
</tr>
<tr>
<td>Incremental CE v. Next Option</td>
<td>$2,877/ton</td>
<td>$6,139/ton</td>
<td></td>
</tr>
</tbody>
</table>

**Implications:**

- Using the EPA methodology, in the CATF reference case the average cost effectiveness of IGCC is less than that for SCPC
- The incremental cost effectiveness of IGCC, compared to SCPC, is not unacceptable
CATF evaluated the sensitivity of the BACT cost-effectiveness result by calculating the ratio of the average cost effectiveness ($/ton) of IGCC-0 to the average cost effectiveness of PC-1 ($/ton) for a range of input assumptions. This quantity is termed “rCE”

- rCE = [CE for IGCC-0] / [CE for PC-1]

Sensitivity to various input assumptions are indicated on the next two slides

- Uniform capital cost increase (the same factor applied to all plants)
- Fuel cost increase (same for all plants)
- CO2 allowance cost (same for all plants)
- Capital cost differential (capital cost of IGCC-0 relative to PC-1)
Sensitivity of rCE to Overall Capital and Fuel Costs

Fuel Cost ($/MMBtu)

Capital Cost Level
(all plants relative to reference case)
CATF Illustration – Sensitivity Analysis

Sensitivity of rCE to Relative Capital and CO2 Costs

- rCE = 1.15
- rCE = 0.85
- rCE = 1.0

IGCC-O Capital Cost Delta v. PC-1 (%)

CO2 Allowance Price ($/ton)
• Criteria pollutant control for IGCC costs slightly more (in $/ton terms) than for PC under assumptions of “yesterday’s world”

• CO2 allowance prices are a key consideration, even for plants without carbon capture and storage (“CCS”)

• Criteria pollutant control for IGCC costs less (in $/ton terms) than PC even under moderate assumptions of “tomorrow’s world” (e.g., CO2 allowances at $5/ton)
Thank You

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