Air Permitting for Gasification and IGCC Plants

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Topics

• How does IGCC compare to PC and NGCC?
• Applicable regulations for IGCC
• New Source Performance Standards for IGCC
• Emission controls for gasification and IGCC
• IGCC emission rate comparison charts
• Startup and shutdown emissions
## Technology Comparison

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>PC</th>
<th>NGCC</th>
<th>IGCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>Coal</td>
<td>Natural gas</td>
<td>Syngas</td>
</tr>
<tr>
<td>Combustion</td>
<td>Coal in boiler</td>
<td>Natural gas in gas turbine</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>Clean fuel and SCR</td>
<td>Pre-combustion clean-up of small volume of syngas</td>
</tr>
</tbody>
</table>
What Regulations Apply to IGCC?
New Source Performance Standards

• IGCC is covered under Subpart Da as an Electric Utility Steam Generating Unit (just like PC boilers) 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”

• IGCC gas turbines are **not** covered by Subpart KKKK, even when natural gas is combusted
### NSPS for IGCC

<table>
<thead>
<tr>
<th>Emission</th>
<th>NSPS</th>
<th>NSPS on Gasifier Input Basis (calculated)</th>
<th>NSPS on Gas Turbine Input Basis (calculated)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NOx</strong></td>
<td>1.0 lb/MWh*</td>
<td>0.143 lb/MMBtu</td>
<td>0.188 lb/MMBtu</td>
</tr>
<tr>
<td><strong>SO₂</strong></td>
<td>1.4 lb/MWh* and minimum 95% removal</td>
<td>0.2 lb/MMBtu</td>
<td>0.263 lb/MMBtu</td>
</tr>
<tr>
<td><strong>Particulate Matter</strong></td>
<td>Lesser of 0.14 lb/MWh* or 0.015 lb/MMBtu**</td>
<td>0.011 lb/MMBtu</td>
<td>0.015 lb/MMBtu**</td>
</tr>
<tr>
<td><strong>Mercury</strong></td>
<td>20 x 10⁻⁶ lb/MWh*</td>
<td>2.87 lb/TBtu</td>
<td>3.75 lb/TBtu</td>
</tr>
</tbody>
</table>

*Output-based standards are on a gross generation basis

** Gas turbine heat input basis, filterable PM only
## Comparison of Air Emission Controls: PC vs. IGCC

<table>
<thead>
<tr>
<th></th>
<th>SO$_2$</th>
<th>NOx</th>
<th>PM</th>
<th>Mercury</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PC</strong></td>
<td>FGD system</td>
<td>Low-NOx burners and SCR</td>
<td>ESP or baghouse</td>
<td>Inject activated carbon</td>
</tr>
<tr>
<td><strong>IGCC</strong></td>
<td>Acid gas removal system removes H$_2$S and COS from syngas</td>
<td>Syngas saturation and N$_2$ diluent: SCR option</td>
<td>Wet scrubber, high temperature cyclone, candle filter</td>
<td>Pre-sulfided activated carbon bed</td>
</tr>
</tbody>
</table>
IGCC – Sulfur Removal

• Gasification occurs in a **reducing** atmosphere (oxygen-starved)

• Sulfur compounds are liberated as \( \text{H}_2\text{S} \) and \( \text{COS} \), not \( \text{SO}_2 \)

• Sulfur compounds removed by refinery industry technologies to levels ≥99%

• Recovered as molten sulfur or sulfuric acid

• For IGCC, sulfur compounds in the syngas are burned in the gas turbine and become low-level \( \text{SO}_2 \) emissions
IGCC – NOx Reduction

• Controlled by moisturizing the syngas and injecting N\textsubscript{2} diluent
  – dilutes and cools the flame, and reduces thermal NOx

• Gas turbines use diffusion burners vs the dry low NOx burners used in NGCC

• SCR is an option for additional NOx reduction

Source: GE
Air Permitting

• Same coal delivery and handling emission points as a PC plant
• Same HRSG emission points as a NGCC plant
• Similar air permitting requirements
  – Air dispersion modeling
  – BACT analysis
  – Emission controls determination
• Start-up and shutdown emissions are unique
Air Emissions

• Unique emission points depend on technology provider
  – Flare
  – Sulfur Recovery Unit tail gas incinerator
  – Sulfuric Acid Plant stack
  – Tank vent incinerators
  – Air Separation Unit cooling tower
What About SCR for IGCC?

• Technical issues
  – The **fuel** is syngas, not natural gas as in NGCC
  – Ammonium sulfate/bisulfate deposit in the HRSG, causing corrosion and plugging, requiring numerous washdowns and downtime

• Economic Issues
  – No commercial guarantees yet with syngas
  – Deep sulfur removal, i.e. Selexol, is required, at higher capital cost than MDEA
  – May not provide cost effective reductions
NOx BACT

• EPA addressed this in report
• Study notes technical problems with using SCR w/IGCC
• Evaluated 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
Emission Rate Units

• Some IGCC permits list emission rates in lb/MMBtu of gasifier (coal) heat input

• Others list emission rates on gas turbine (syngas) heat input basis (like NGCC)

• EPA addressed this issue:
  – “The heat input for an IGCC facility is the heat content of the syngas burned in the stationary combustion turbine and not the heat content of the coal fed to the gasification facility. The gasification facility is not part of the affected source under subpart Da, only the stationary combustion turbine (turbine and heat recovery steam generator) are covered.”
Emission Rate Units

• Permit limits are to be expressed on basis of syngas input to the gas turbine

• Permit applications or permits can list “equivalents” on gasifier input basis, as well as lb/hr and ppm

• Important to specify heat input basis in permit application and in permit
### Permit Limit Units - NOx Example

<table>
<thead>
<tr>
<th>NOx Emissions from Gas Turbine</th>
<th>Emission Rate Gasifier (Coal) Input Basis</th>
<th>Emission Rate Gas Turbine (Syngas) Input Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>161 lb/hr</td>
<td>0.059 lb/MMBtu</td>
<td>0.077 lb/MMBtu</td>
</tr>
</tbody>
</table>

30% difference!
## Emission Rate Units

<table>
<thead>
<tr>
<th>EMISSION UNIT</th>
<th>DESCRIPTION</th>
<th>POLLUTANT</th>
<th>EMISSION LIMITATION BASED ON CT HEAT INPUT</th>
<th>EMISSION LIMITATION BASED ON GASIFIER HEAT INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRSG1 &amp; HRSG2</td>
<td>Combustion Turbine 1 &amp; 2 (each)</td>
<td>PM$<em>{10}$ fineable (Syngas &amp; Natural gas) PM$</em>{10}$ Total</td>
<td>0.0085 lb/MMBtu 0.0217 lb/MMBtu</td>
<td>0.0083 lb/MMBtu filterable (BACT) 0.0161 lb/MMBtu Total</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Opacity</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CO – syngas</td>
<td>0.0485 lb/MMBtu</td>
<td>0.036 lb/MMBtu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CO - natural gas</td>
<td>0.0449 lb/MMBtu</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>NO$_x$ syngas</td>
<td>0.0331 lb/MMBtu</td>
<td>0.0246 lb/MMBtu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NO$_x$ natural gas</td>
<td>0.0246 lb/MMBtu</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SO$_2$ – syngas</td>
<td>0.0158 lb/MMBtu</td>
<td>0.0117 lb/MMBtu (BACT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SO$_2$ - natural gas</td>
<td>0.001 lb/MMBtu</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VOC – syngas</td>
<td>0.0015 lb/MMBtu</td>
<td>0.0011 lb/MMBtu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VOC natural gas</td>
<td>0.0017 lb/MMBtu</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>H$_2$SO$_4$ – syngas</td>
<td>0.0035 lb/MMBtu</td>
<td>0.0026 lb/MMBtu (BACT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H$_2$SO$_4$ - natural gas</td>
<td>0.0001 lb/MMBtu</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hg – syngas</td>
<td>20 x 10$^{-6}$ lbs/MWh</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hg - natural gas</td>
<td>2.6 x 10$^{-7}$ lbs/MMscf$^*$</td>
<td></td>
</tr>
</tbody>
</table>

Source: KY DAQ – Cash Creek Generation permit
# Emission Rate Units

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging Period</th>
<th>Units</th>
<th>Operating Case</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 - Syn</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0°F Amb.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100% Load</td>
</tr>
<tr>
<td>Operating Hours</td>
<td>Annual</td>
<td>hr/yr</td>
<td>0.730</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>MW, gross</td>
<td>413.3</td>
</tr>
<tr>
<td>Gasifier Heat Input</td>
<td>Max. Hourly</td>
<td>10² Btu/hr (HHV)</td>
<td>3,200</td>
</tr>
<tr>
<td>CT Heat Input</td>
<td>Max. Hourly</td>
<td>10² Btu/hr (HHV)</td>
<td>2,571</td>
</tr>
<tr>
<td>NOx</td>
<td>30-day Rolling</td>
<td>lb / 10⁶ Btu²</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>Rolling</td>
<td>lb / MWh, gross</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ppmv @ 15% O₂</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N/A</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N/A</td>
<td>12.9</td>
</tr>
</tbody>
</table>
Permit Limit Comparisons

- Publicly available information
  - Permit applications
  - Draft permits
  - Final permits
  - Submittals to other agencies
  - Some units have been cancelled

- Values are provided on gasifier and gas turbine heat input bases
NOx Emission Rate Comparison
Gasifier Heat Input Basis

<table>
<thead>
<tr>
<th>Company</th>
<th>NOx Emission Rate (Lb/MMBtu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEP - Mountaineer</td>
<td>0.06</td>
</tr>
<tr>
<td>Mississippi Power</td>
<td>0.06</td>
</tr>
<tr>
<td>Duke Energy Indiana Edwardsport</td>
<td>0.06</td>
</tr>
<tr>
<td>Excelsior - Mesaba</td>
<td>0.06</td>
</tr>
<tr>
<td>Taylorville Energy Center</td>
<td>0.06</td>
</tr>
</tbody>
</table>

SCR
NOx Emission Rate Comparison
Gas Turbine Heat Input Basis

Lb/MMBtu

NOx

AEP - Mountaineer
Mississippi Power
Duke Energy Indiana Edwardsport
Excelsior - Mesaba
Taylorville Energy Center
SO$_2$ Emission Rate Comparison
Gasifier Heat Input Basis

Lb/MMBtu

0.035
0.03
0.025
0.02
0.015
0.01
0.005
0

SO2

AEP - Mountaineer
Mississippi Power
Duke Energy Indiana Edwardsport
Excelsior Energy - Mesaba
Taylorville Energy Center
SO$_2$ Emission Rate Comparison
Gas Turbine Heat Input Basis

- AEP - Mountaineer
- Mississippi Power
- Duke Energy Indiana Edwardsport
- Excelsior Energy - Mesaba
- Taylorville Energy Center
Mercury Removal

- Pre-sulfided activated carbon beds
- >94% removal of vapor-phase mercury at Eastman Chemical
- Forms a mercury-sulfur complex
- Spent carbon disposed of in drums
- IGCC plants will use this technology

Source: Eastman Chemical
Start-up and Shutdown Emissions

• Can be a significant source of annual emissions

• Dependent on:
  – Number of start-ups and shutdowns
  – Duration of startups
  – Startup procedures, i.e. starting first gasifier, then second, or both in parallel
  – Startup “fuel”
  – Flaring of raw/treated syngas or acid gas
  – Use of design/operational considerations to minimize emissions
Start-up and Shutdown Emissions

• Identify start-up and shutdown emissions for initial operation and for a mature plant
  – Permit application should clarify these emissions and timeframes so as not to limit normal plant operations

• Industry has made design and operational enhancements to minimize these emissions
  – Using start-up absorbers
  – Low-sulfur start-up fuels
  – Oxidizing CO in vent streams to CO₂
Questions?
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