CO$_2$ Capture at the Kemper County IGCC Project

2011 NETL CO$_2$ Capture Technology Meeting
Kemper County IGCC Overview

- 2x1 Integrated Gasification Combined Cycle (IGCC)
  - 2 TRansport Integrated Gasifiers (TRIG™)
  - 2 Siemens SGT6 - 5000F CTs
  - 1 Toshiba Steam Turbine (Tandem Compound Double Flow)
  - 582 MW peak and 524 MW on syngas
  - Heat Rate 11,708 Btu/kWh (29.5% HHV Efficiency w/ CO₂ control and 40+% moisture coal)
  - Selexol for H₂S and CO₂ removal
  - 65+% CO₂ capture (~800 lb/MWh emission rate)
  - Mine Mouth Lignite

- Owner & Operator: Mississippi Power
- Over $2 billion capital investment
- Commercial Operating Date: May 2014
- Use treated effluent from Meridian as makeup water
- By-Products (TPY)
  - ~3,000,000 - Carbon dioxide used for EOR
  - ~135,000 - Sulfuric acid
  - ~20,000 - Ammonia

Kemper Lignite Composition

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<thead>
<tr>
<th></th>
<th>Average</th>
<th>Min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>Heat Content</td>
<td>btu/lb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur</td>
<td>%</td>
<td></td>
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</tr>
</tbody>
</table>

- Heat Content: btu/lb
  - Average: 5,290
  - Min: 4,765
  - Max: 5,870

- Moisture: %
  - Average: 45.5
  - Min: 42
  - Max: 50

- Ash: %
  - Average: 12.0
  - Min: 8.6
  - Max: 17

- Sulfur: %
  - Average: 1.0
  - Min: 0.35
  - Max: 1.7

Distribution of coal-bearing units in the Gulf Region
Proposed Kemper County IGCC Project Map

- ~70 miles transmission
- ~60 miles CO₂ pipeline (for EOR)
- ~5 miles natural gas pipeline
- ~31,000 acre mine site
- ~2,900 acres plant site
- ~30 miles treated effluent line
TRIG™
Attributes/Advantages

- **Simple, well established design**
  - Based on technology in use for 70 years

- **Either Air- or Oxygen-blown**
  - Air for power
  - Oxygen for liquid fuels and chemicals

- **High Reliability Design**
  - Non-slagging design:
    - Provides 10-20 year refractory life,
    - Eliminates black water system
    - Provides non-fouling syngas cooler operation
  - No burners to fail and be replaced
  - Dry dust removal eliminates gray water system

- **Lower Fuel Costs**
  - Coarse, dry coal feed allows:
    - Fewer, lower power pulverizers, and
    - Less drying than other dry-feed gasifiers
  - Cost-effective using high moisture, high-ash, low rank coals (PRB and lignite).

- **Excellent Environmental Performance**
  - Lower water use compared to pulverized coal (PC)
  - Excellent emissions performance
  - Easier to permit compared to PC
  - Lower cost carbon capture compared to PC
Summary Flow Diagram

Gasifier Island

Coal Milling & Drying → High Pressure Coal Feeding → Transport Gasifier → Coal Gasification → Syngas → High Temperature Syngas Cooling → Particulate Collection → Water Gas Shift Reaction → Low Temperature Syngas Cooling → CO2 and Sulfur Removal → CO2 Compression and Drying

CO2 Compression and Drying → CO2

CO2 and Sulfur Removal → Mercury Removal

Syngas → Sour Water Treatment → Sour Water

Sour Water → Anhydrous Ammonia → Ammonia Recovery

Ammonia Recovery → Recycle Gas Compression

Recycle Gas Compression → Recycle Gas

Recycle Gas → Water from Coal Drying

Water from Coal Drying → Coal Milling & Drying

Coal Milling & Drying → Process Air Compressor → Air

Air → Transport Gasifier → Transport Gasifier

Transport Gasifier → High Pressure Coal Feeding → Coal Milling & Drying

Combined Cycle

Heat Recovery Steam Generator → Gas Turbine

Gas Turbine → Power

Power → Condenser

Condenser → Steam Turbine

Steam Turbine → Power

Power → Condensate

Condensate → HP, Superheated Steam

HP, Superheated Steam → Condenser

Condenser → Steam Turbine

Steam Turbine → Power

Power → Condensate

Energy to Serve Your World
Evolution of Acid Gas Removal at Kemper County IGCC

- Originally, no CO₂ removal. H₂S removed with amine.
- With CO₂ removal added to scope, design team explored three main options based on a physical solvent:
  - 25% CO₂ removal (1,500 lb CO₂/MWh).
    - Case 1: No WGS, Selexol for sulfur removal, amine for CO₂
    - Case 1A: One stage of WGS, with Selexol for all acid gas removal.
  - 50% CO₂ removal (1,000 lb CO₂/MWh).
    - Case 2: One Stage WGS with steam injection with Selexol for AGR.
    - Case 2A: Case 1A retrofitted to Case 2 in 2020
    - Case 2B: Case 1 retrofitted to Case 2 in 2020.
  - 65% CO₂ removal (800 lb CO₂/MWh).
    - Case 3: Two stages WGS with steam injection and Selexol for AGR.
The operating costs for an amine were too expensive, due to high steam usage for regeneration. Therefore, a physical solvent was selected.

<table>
<thead>
<tr>
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<th>Selexol</th>
<th>Rectisol</th>
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<tbody>
<tr>
<td>Volatility</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Solvent Price</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Emissions Concern</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
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Both good options, but Selexol was chosen.
The CO₂ Capture Scheme for 800 lb/MWh:

- **Two Stages WGS**
- **Selexol Physical Solvent**
- **Refrigerated to 40 F**

**Carbon Capture**: >65%

**CO₂ Emissions**: 800 lb CO₂/MWh

**Yield**: >3 MM Tons/yr CO₂

**CO₂** compressed and used for EOR

**Acid gas** converted to sulfuric acid via WSA process.
Kemper County IGCC

- Water Supply Pond
- Warehouse
- Water Treatment
- Process Air Compressors
- Control/Admin Bldg.
- Gasifier Structure: Gasifiers, Syngas Cooling/Filtration
- Coal Loading Hoppers
- Coal Prep
- Flare
- Sulfuric Acid Production
- Cooling Towers
- 2 x 1 Combined Cycle
- Sulfur/CO2 Removal
- Electrical Switchyard
- 2 x 1 Combined Cycle
- Control/Admin Bldg.
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Fluid Bed Dryer System

Sulfuric Acid Production

Nitrogen Plant

CO₂ and H₂S Removal

Gas Turbines

Steam Turbine

Air Compressors

HRSGs

HP Coal Feeders

Gasifiers (2)

Fluid Bed Dryer System

Nitrogen Plant

CO₂ and H₂S Removal

HRSGs

Steam Turbine

Air Compressors

Gasifiers (2)

Nitrogen Plant

CO₂ and H₂S Removal

HRSGs

Steam Turbine

Air Compressors

Gasifiers (2)

Nitrogen Plant

CO₂ and H₂S Removal

HRSGs

Steam Turbine

Air Compressors

Gasifiers (2)

Nitrogen Plant

CO₂ and H₂S Removal

HRSGs

Steam Turbine

Air Compressors

Gasifiers (2)

Nitrogen Plant

CO₂ and H₂S Removal

HRSGs

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Nitrogen Plant

CO₂ and H₂S Removal

HRSGs

Steam Turbine

Air Compressors

Gasifiers (2)

Nitrogen Plant

CO₂ and H₂S Removal

HRSGs

Steam Turbine

Air Compressors

Gasifiers (2)

Nitrogen Plant

CO₂ and H₂S Removal

HRSGs

Steam Turbine

Air Compressors

Gasifiers (2)
On June 3, 2010, the Mississippi Public Service Commission certified the project.

Mississippi Power has entered into CO2 offtake agreements with Denbury Onshore and Treetop Midstream Services, LLC.

MDEQ issued the final PSD permit on March 9, 2010.

Procurement: All major equipment awarded. Equipment fabrication underway. First major pieces arriving on site.

Construction: Site cleared and graded. Foundation and pedestal work underway. Sumps, duct banks, underground piping being installed.
Kemper Procurement Update
2nd Quarter - 2011

Top of CO₂ Absorber
Base of CO₂ Absorber
Base of Concentrator
Lean/Rich Exchanger Plates
Kemper County IGCC Construction Update

1st Quarter - 2011

- Storm Drains
- Electrical Duct Banks
- Fire Protection Piping

Began Installation of Underground Electrical and Mechanical Systems
Kemper County IGCC Construction Update

2nd Quarter - 2011

Steam Turbine Columns

AGR Area Sumps

96” Circ. Water Pipe

Deep Foundations/ Major Equipment Foundation Installation/U/G Utilities
Kemper County IGCC Construction Update

End of 2nd Quarter - 2011

Steam Turbine Operating Deck
Circulating Water Pipe
Plant Site as of July 2011
Gasifier Pile Caps/Deep Foundation Installation
Physical solvents were selected for the Kemper design due to reduced steam usage.

The facility will use Selexol coupled with two stages of water-gas-shift, resulting in a CO$_2$ emission rate of 800 lb/MWh (a nominal 65% reduction).

3 million tons/year of CO$_2$ captured at the Kemper site will be used for EOR, and will meet offtaker specifications.

Commercial operations are expected in May 2014.