Piperazine Advanced Stripper (PZAS™) Front End Engineering Design (FEED) Study

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U.S. Department of Energy
National Energy Technology Laboratory
Carbon Management and Natural Gas & Oil Research Project Review Meeting
Virtual Meetings August 2 through August 31, 2021
Agenda

• Overview and Objectives
• Site Info
• Technology Details and Layout
• Purchased Equipment Costs
• Schedule
• Takeaways
Program Overview

- Funding ($5.4 MM)
  - 4.1 MM DOE
  - 1.1 MM cost sharing- ExxonMobil, Total, Chevron
  - 0.3 MM from Honeywell UOP outside DOE

- Expected Performance Dates: 10/2019 – 3/2022

- Project Participants
  - Golden Spread Electric Cooperative (GSEC) – Host
  - University of Texas at Austin (UT) – Modeling/ Technology
  - Trimeric – Process Engineering
  - AECOM – EPC
The Objective: Accurate installed cost of PZAS™ on NGCC at GSEC Mustang Station

Complementary Benefits:

• Develop commercial project at Mustang Station
• Qualify PZAS for use on NGCC cogen
• Provide commercial cost detail
• Optimize PZAS & other 2G capture processes
• Guide R&D of capture technology
Host Site - Mustang Station
Golden Spread Electric Cooperative
Denver City, TX Cooperative
Southwest Power Pool
460 MW NGCC
2 GT/1 ST
West Texas Permian Basin
Available land
Cheap Gas from Waha
CO₂ sales for EOR
CO₂ pipeline one mile south
No cooling water for Capture
Southwest Power Pool, August 2021
Gas-fired power to back up wind

Total projected load

Projected Available Wind
Southwest Power Pool, August 2021

Gas-fired plants to back up wind power.

- Total projected load: 50,000 MW
- Projected Available Wind: 37% GAS, 43% COAL
- Graph showing daily load and generation for the week of August 2021.
PZAS™ for NGCC

5 molal piperazine:
- 2X CO₂ absorption rate of MEA
- Loss rate <0.3 kg/ton CO₂
- Tolerates 150 °C/7 bar stripper

90% capture

Stack

Water Wash

Absorber

Flue Gas

CO₂ Product

Compressors and Coolers

CO₂ Exchanger

CO₂ Cooler

No Solvent Bypass

Cold Rich Bypass

Warm Rich Bypass

Steam Heater

Hot Cross Exchanger

Cold Cross Exchanger

No DCC

Pump-around Intercooling
Air cooling dominates plot plan
25% of purchased equipment cost

Two Gas Turbines w HRSGs and Stacks
90% Capture (190 tonne/hr) in Two Absorbers
• Each train treats all flue gas from 1 GT and one new boiler
• Turndown to match Mustang Station operation
• Off-site fabrication of large equipment
• Sequenced construction
Absorber Design

- Two 40 x 47 ft rectangular absorbers
- Two absorber beds and one water wash section, with pump-around intercooling
  - Total packing height = 35 ft
  - Total absorber height = 117 ft
- Max sump depth = 18 ft with Vertical sump pump to reduce NPSH
- 40 ft cylindrical stack on top of absorber dictated by CEMS
Absorber Cost dominated by Shell, not Packing

- Shop and field-construction costs in progress
- Costs for materials and shop fabrication estimated to be ~$20M
- Shell costs ~80% of total (including internals but not foundations and platforming)
Advanced Stripper

11-ft diameter stripper
Shop fabricated
Plate & Frame Exchangers sized to provide 2.85 GJ/t CO$_2$
Consistent with low cost gas

Lean Pumps
Ductwork and Boilers

2 package boilers to provide steam increases gas rate by 7%, CO₂ by 20%

Tie in to Existing stacks

2 Fans/Abs

Gas Boiler
Inlet duct CFD

- Discharge from fans
- Boiler Flue Gas Inlet
- Absorber
All cooling by air

• API 661 standard
• Materials of Construction – 304SS with aluminum fins
• Nominal approach temperature 11°C

<table>
<thead>
<tr>
<th>Air Coolers</th>
<th>% of Total Air Cooler Cost</th>
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<tbody>
<tr>
<td>Absorber Intercoolers</td>
<td>~52%</td>
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<tr>
<td>Wash Water Coolers</td>
<td>~45%</td>
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<tr>
<td>CO₂ Coolers</td>
<td>~3%</td>
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</table>
Wash Water Air Cooling, 18 bays for each train

- Water Storage
  - Allows 24-hour cycle
  - To balance on hot days

- 3 pass uses piping on both sides
Compressors

• Low-speed reciprocating machine w automatic load reduction
  o One 9,100 hp compressor/process train
  o Better turndown than integrally-geared centrifugal design
  o Higher stripper P of PZAS™ (5 -6 bar) reduces power & capital

• Interstage cooling by air

• TEG Dehydration around 14% of total compressor package cost
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<thead>
<tr>
<th>Equipment</th>
<th>Purchase Cost ($ x 10^6)</th>
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<td>Air coolers</td>
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<td>Absorber</td>
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<tr>
<td>Compressors</td>
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<tr>
<td>Reclaiming/Solvent treatment</td>
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<td>Packaged boilers</td>
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<td>Exchangers</td>
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<tr>
<td>Stripper</td>
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<td>Fans</td>
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<tr>
<td>Process BOP</td>
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<tr>
<td><strong>Total PEC</strong></td>
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<tr>
<td>Kick Off Meeting; DOE</td>
<td>Feb 2020</td>
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<tr>
<td>Virtual Kick Off; Mustang Station</td>
<td>Mar 2020</td>
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<td>Project Design Basis</td>
<td>Aug 2020</td>
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<td>Baseline Process Design</td>
<td>Aug 2020</td>
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<td>Equipment Lists</td>
<td>April 2021</td>
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<td>Electrical One-Lines</td>
<td>July 2021</td>
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<td>CapEx</td>
<td>Oct 2021</td>
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<td>Process Modeling Report</td>
<td>Dec 2021</td>
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<td>FEED Report</td>
<td>Mar 2022</td>
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Takeaways

- 90% CO₂ capture (190 tonne/hr)
- Total cost of purchased equipment is $122 million
  - Absorbers and air coolers are 50% of the total
- Available land provides easily accessible general arrangement
- Two parallel trains provide flexibility during construction and operation
- 80% of absorber cost is the shell
  - Packing is only 30% of total absorber height
- Dry air cooling is suited to provide all cooling duties
- Reciprocating compressors used with 6 bar stripper and 50% turndown
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