Carbon Sequestration Leadership Forum

2015 Technology Workshop
Lessons Learned from Large-Scale CCS
Wednesday June 17, 2015

Kemper County Energy Facility

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Kemper County ENERGY facility

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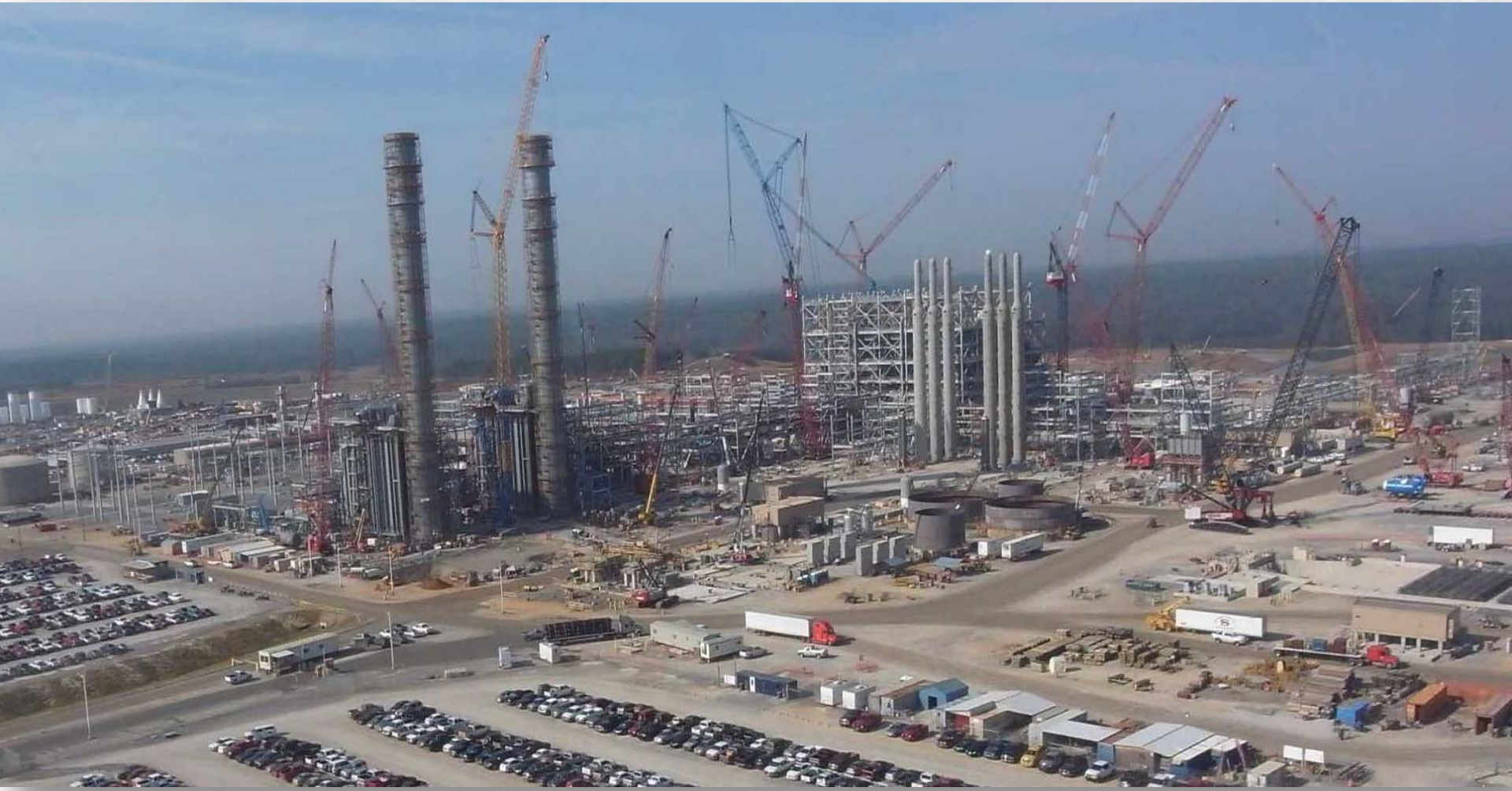
Construction Safety

- 0.46 Project Recordable Incident Rate
  - About 7 times safer than construction industry average for comparable projects
- 34 Million man-hours worked to-date

Construction Progress -- Fall, 2010

Construction Progress -- Fall, 2011

Construction Progress -- Fall, 2012

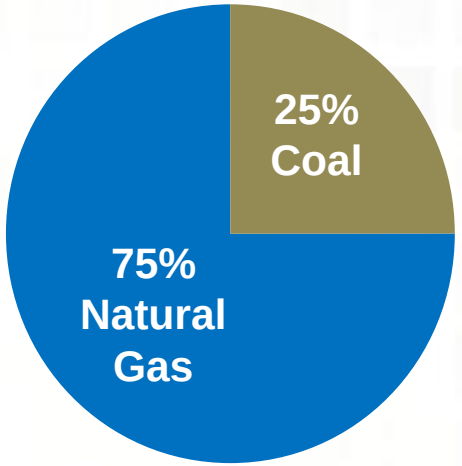


Construction Progress -- Fall, 2013

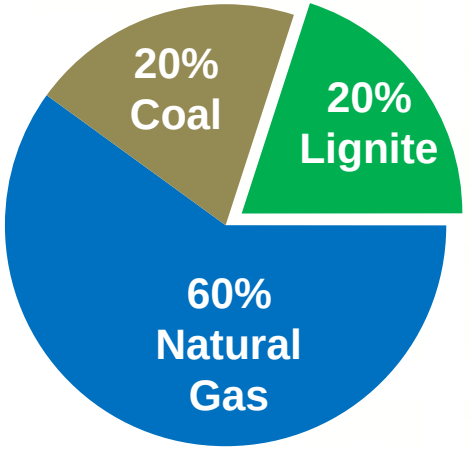
Plant and Mine Aerial View – Fall 2014

Why Kemper?

- Fuel diversity
- Long-term low fuel price stability
- 21st century technology
- Environmental profile
- Inland location



2020 energy mix **without** Kemper



2020 energy mix **with** Kemper *

*** Includes unit retirement and fuel switch announcements (Aug. 4, 2014)**

Kemper County IGCC Infrastructure

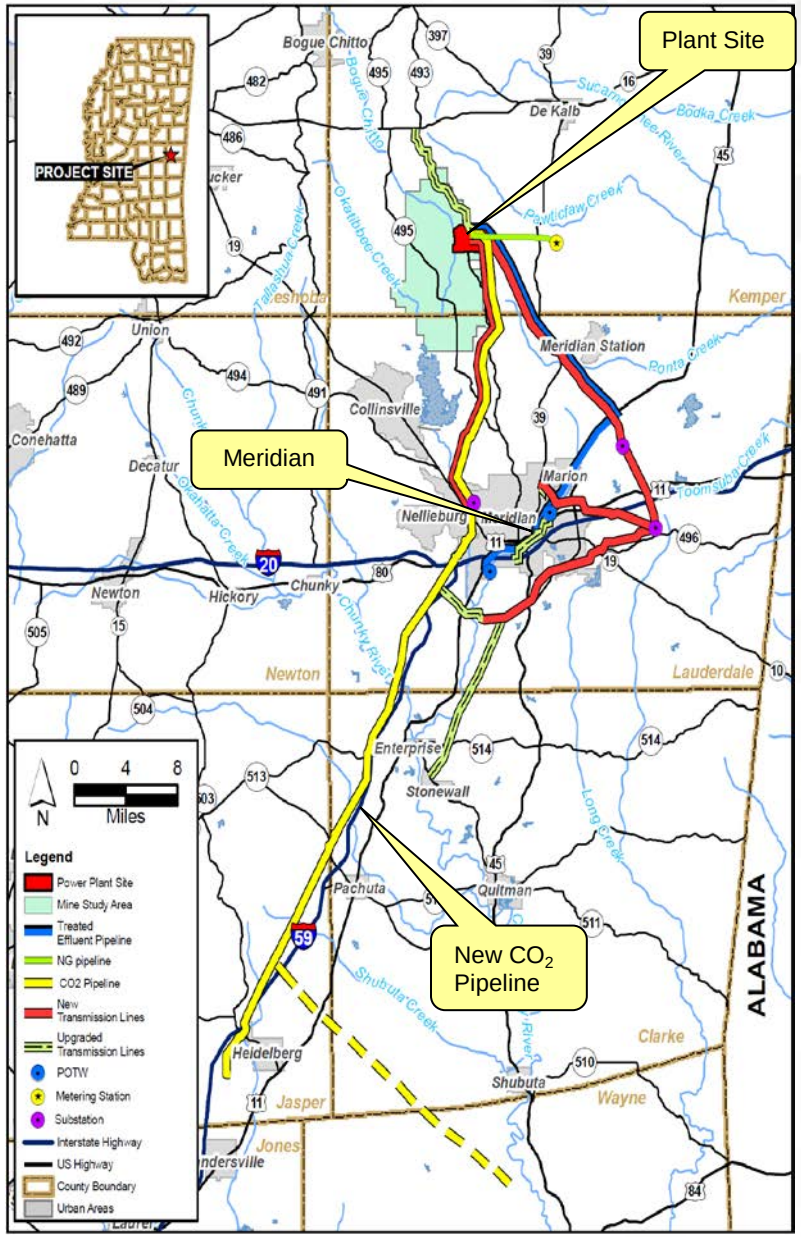
~112 km (70 miles) transmission
- ✓ Station energized

~ 96 km (60 miles) CO_2 pipeline (for EOR)
- ✓ 100% Complete

~8 km (5 miles) natural gas pipeline
- ✓ 100% Complete

~125 km^2 (3,100 acres) mine site.
- ✓ Placed in Service in June 2013

~ 48 km (30 miles) treated effluent line
- ✓ 100% Complete



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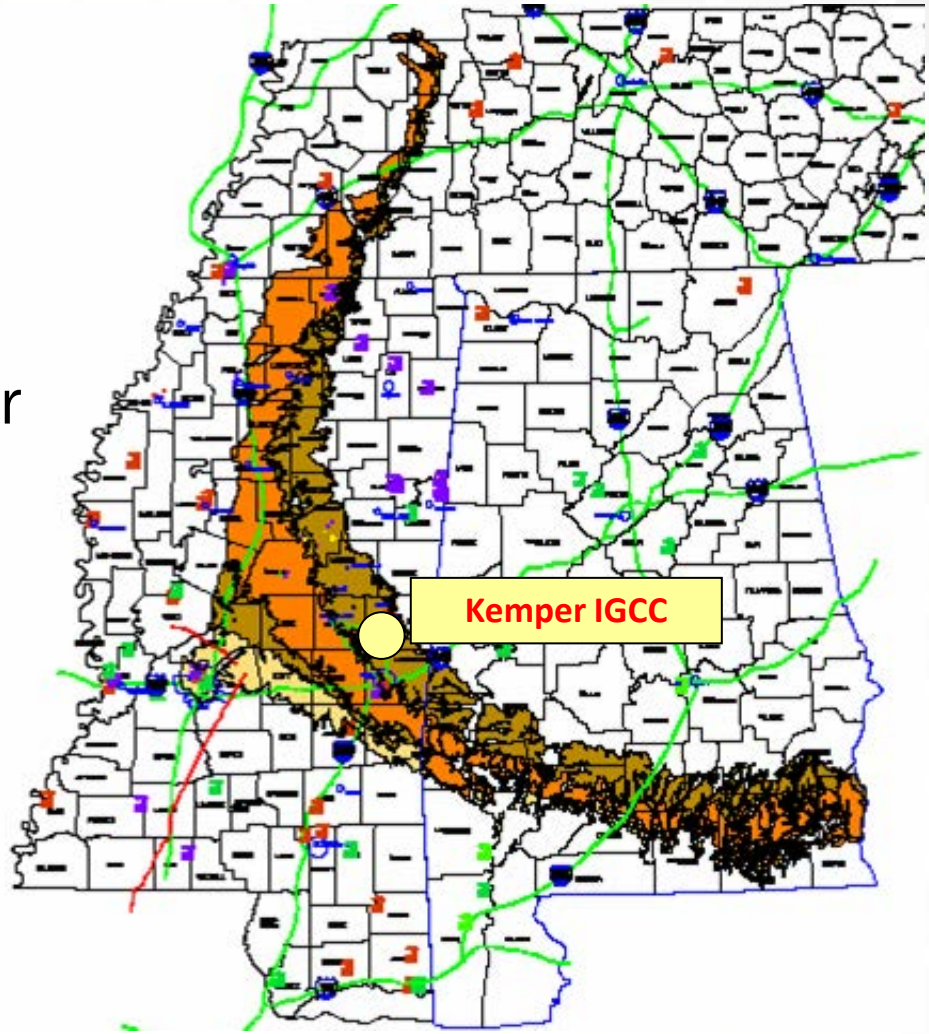
Why Lignite Fuel?

- Natural Mississippi resource
- Estimated 4 billion mineable tons
- 160 million needed for Kemper over 40-year plant life
- Low commercial value at 5K btu/lb and 45% moisture
- TRIG™ technology designed for coals like lignite



Mississippi Lignite Mining

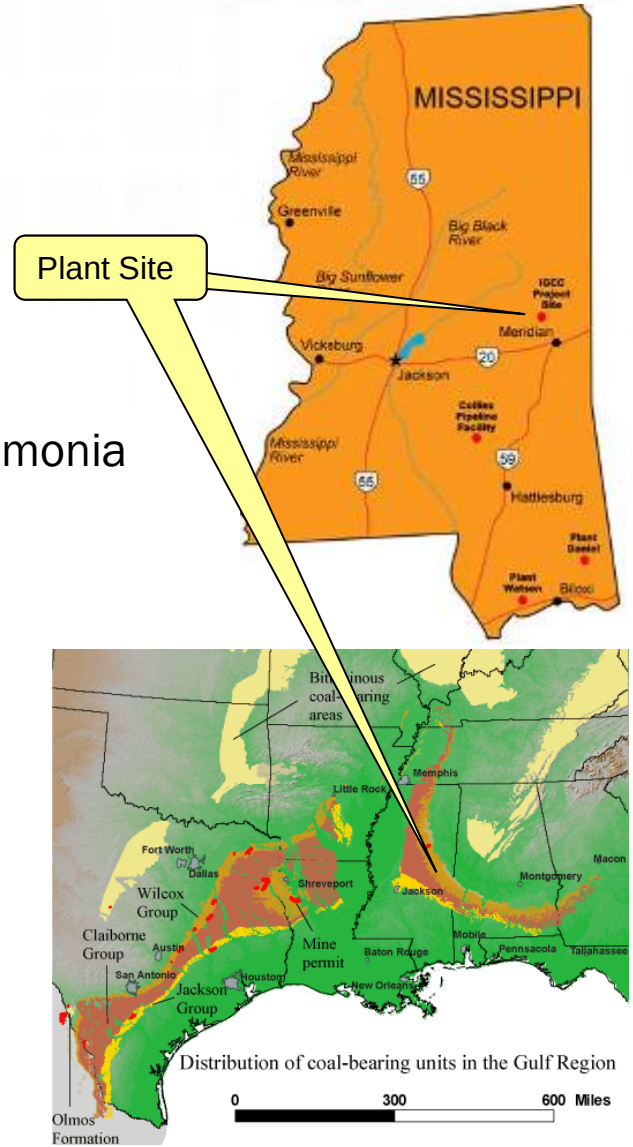
- Surface mine operations
- Multiple seams
- Typically seam is between 2–10 feet thick
- Shallow deposits at between 100 to 300 feet deep

Economic Benefits

- $1 Billion in Mississippi contracts
- 12,000 direct and indirect jobs
- 500 Mississippi companies
- 500 permanent employees
- $75 Million state and local taxes during construction
- $30 Million state and local taxes annually in operation

Project overview

- **2x1 Integrated Gasification Combined Cycle (IGCC)**
  - 2 Transport Gasifiers
  - 2 Siemens SGT6 - 5000F gas turbines
  - 1 Toshiba steam turbine
  - 740 MW gross capacity; 582 MW net peak capacity
  - Chemical products: carbon dioxide, sulfuric acid, ammonia
- **Project Information**
  - Mine-mouth Lignite (brown coal)
  - Zero liquid discharge
  - Uses treated effluent as makeup water
- **Mine**
  - Commercial operation; June 5, 2013
  - Dragline in-service; Fall 2013
  - More than 1 million tons of lignite mined to date
  - Some 20 acres of mined property already reclaimed



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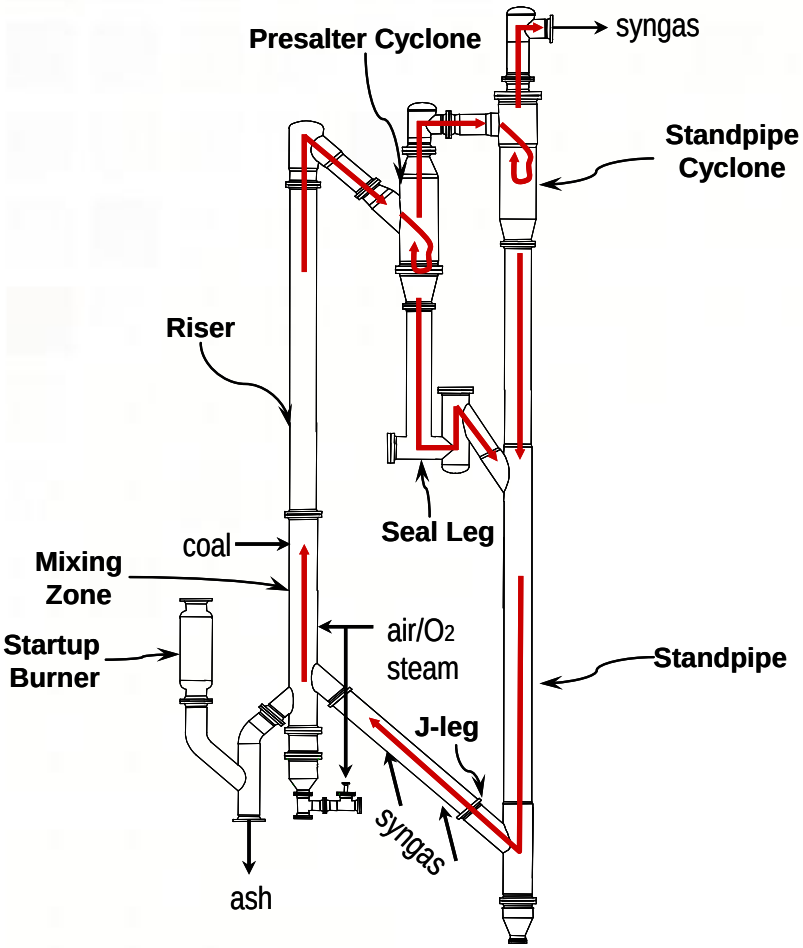
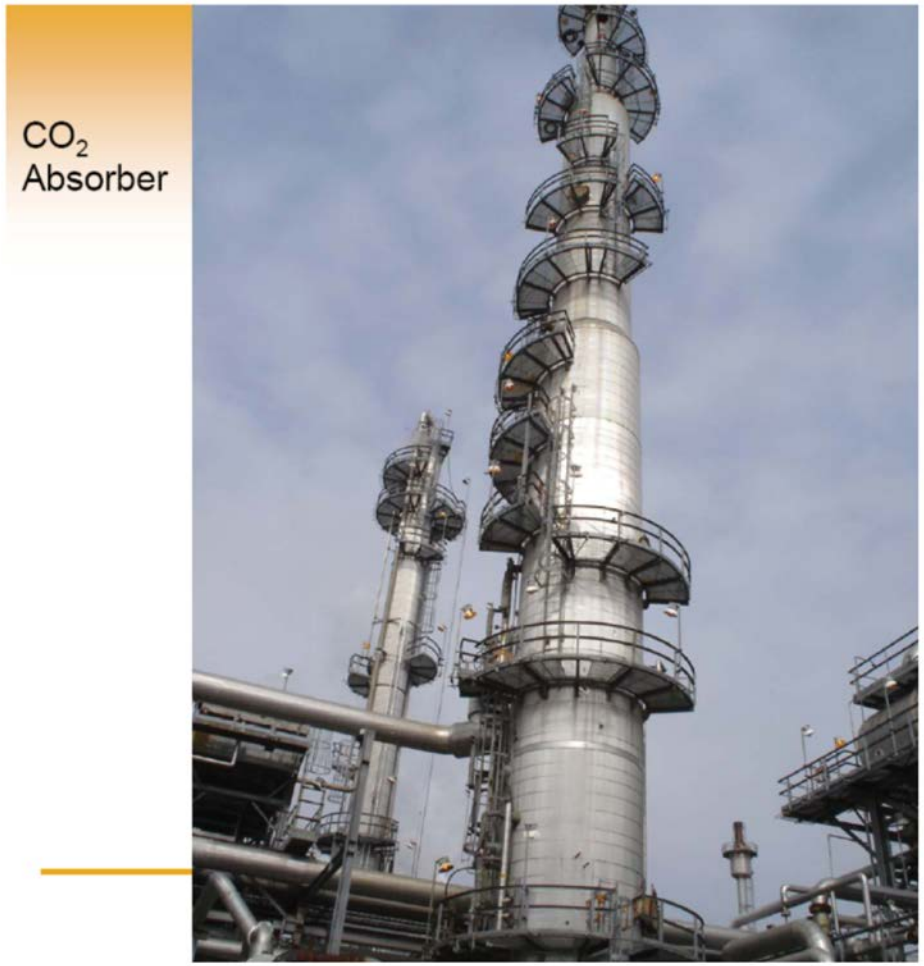
Transport Integrated Gasification (TRIG™)



- Simple, well established design
- Either air- or oxygen-blown
- High reliability design, non-slagging design
- Designed for low-rank coal; lowers fuel costs
- Excellent environmental performance

Gasifier as Installed

UOP selexol process for CO_2 capture



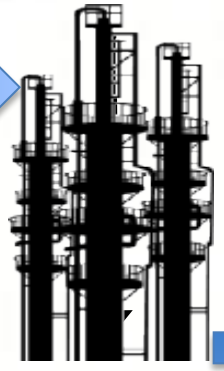
- 65 percent carbon capture – similar carbon footprint to a NGCC
- Stable, well-proved process that uses a single solvent to remove both CO_2 and H_2S
- Relies on acid gas physical solubility in solvent
- Uses equipment common in the chemical and refining industries
- More than 50 units are in commercial operation

A sense of scale -- H_2S Absorbers

Syngas Clean-Up Equipment

Saleable by-products

Gasifier



Combined Cycle

Sulfuric acid (H_2SO_4)
~150,000 Tons/Year

20/day

Ammonia (NH_3)
~19,000 Tons/Year

4/day

CO_2 @ 65% capture
~3,800,000 Tons/Year

Kemper Update Q2, 2015

- **Construction**
  - 99 percent complete
  - Support for startup and operations now through COD
- **Startup Milestones**
  - Gasifier “first fire” occurred first week in March, 2015
  - Hundreds of systems to test. Next milestones:
  - Refractory drying, Fluidization test, first lignite feed,
  - First Syngas by late 2015
- **Operations**
  - O&M and PSM training in progress
  - Team participation in startup and commissioning
- **Combined Cycle**
  - CC in service Aug. 9, 2014
  - EFOR around 1 percent since in service date
- **Mine**
  - 1 million tons of lignite mined, 20 acres reclaimed

Lessons Learned During Kemper Construction and Startup Phase to Date

- FOAK engineering design should be further completed as construction began;
  - Ex. Carbon capture went from 0% to 25% to 50% to 65%
- Integrate Operations Group more heavily in design;
  - Ex. Compressed design of plant benefitted construction costs with reduced piping but was challenging with construction operations and re-construction access when issues were identified
- Schedule not driven by targets predetermined too early or for other reasons;
  - Ex. No basis for how long construction should take, i.e. do not pick a date for completion and back into it. Ultimately had to established a re-baseline schedule.

Lessons Learned During Kemper Construction and Startup Phase to Date

- Process safety management pre-planning;
  - Ex. PSM with a chemical pant was underestimated as this took more time to install systems and train employees
- Begin operational staffing plan and training early;
  - Ex. Utilities have more institution knowledge in mechanical and electrical engineering and the plant requires more chemical engineers

Example of unanticipated FOAK issues

- Ceramic lining of the gasifier
  - An issue was encountered with the ceramic refractory lining of the gasifier; this was not a design issue but a materials issue and required reformulation and installation of materials
- Lignite drying operations equipment
  - The lignite drying system utilizes dryer fans coupled to 6 separate 7,000 hp motors installed together. This assemble was a FOAK and after installation the fan motors, based on differential heat expansion, resulting in vibration

Lignite Delivery Facility

LDF Area


Stacker Reclaimer


Coal Tripper Room Floor


LDF Area

Gasifier

Gasifier

Steam Piping from Syngas Coolers

Insulated Heat Exchanger

Control Valves

Gas Cleanup & By Products

Acid Gas Recovery

Sulphuric Acid Plant

Water Gas Shift Reactors

Process Air Compressors

Combined Cycle

Global Technology Interest

- Wall Street Journal; Atlantic Council; China Ministry of Science and Technology; Japanese nationals; Polish diplomatic core; Los Angeles Times; The Guardian newspaper(UK); Bloomberg News; North Dakota Public Utilities staff; National Geographic Magazine; NHK Japan; New York Times; representatives from the California Legislature; Navajo Nation Energy Advisory Committee; Norwegian, Ministry of Petroleum and Energy; Shenhua Electric (China); NOS (Dutch television network); Representatives from the British Consulate General; German delegation from Friburg; MSNBC; Japan Coal and Energy Center; Kawasaki Heavy Industries; Italian delegation with KBR; United Nations climate officials, including Jukka Uosukanian (UN's top climate official; representatives from Hailu Manufacturing (China); J-Coal representatives from Japan; Republic of South Korea government officials (Korean Institute of Energy Research); Chiyoda Corporation (Japan); Energy Ministry of South Korea; CCTV (Chinese television); International Standards Organization ISO (conference held here. Representatives primarily from Japan, Germany, US, Australia, Canada, France, UK and China) APEC (Asia Pacific Economic Corporation) members include Pacific Rim countries, at Kemper most of the delegation was from Mexico, China and the US; SASK Power (Canada); Officials from the Canadian consulate; Politco magazine


Thank You