Southern Company

Kemper County IGCC – Overview and Operational Summary

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Agenda

- Major components and unique features
- Process block flow diagram
- Operational summary and statistics
- Remaining technical challenges
- Conclusions
- Next steps

Timeline and Safety

• Project groundbreaking	June 2010
• Construction begins	First half of 2011
• Combined-cycle in service	Third quarter 2014
• First coal feed to gasifier	July 2016
• Operations suspended	June 28, 2017
• Total project man-hours	41+ MM Recordable Incident Rate (RIR) = 0.42
• Total plant man-hours	~2.5 MM RIR = 0.16

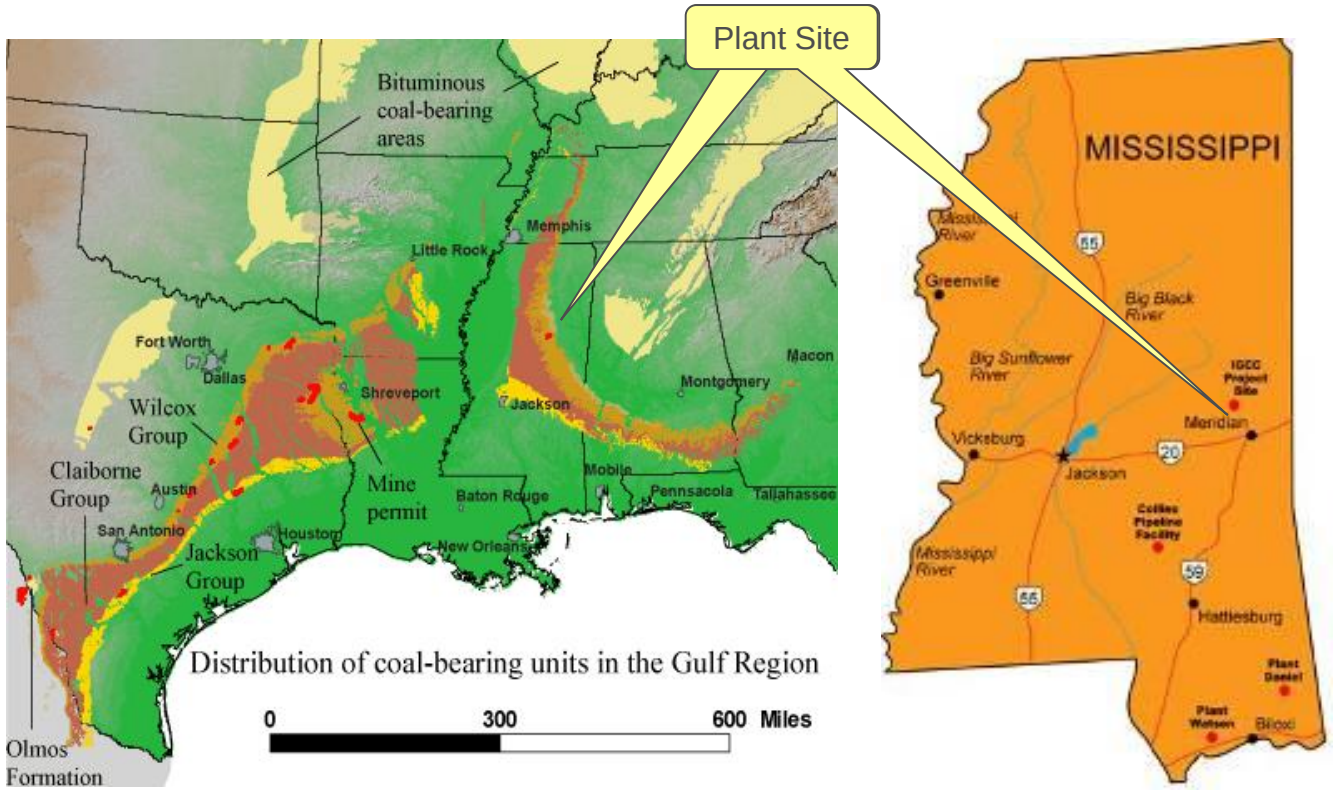
Kemper County IGCC Overview

- **Mine-mouth lignite**

- **2x1 IGCC**
  - Two Transport Gasifiers (TRIG™)
  - Two Siemens SGT6 - 5000F CTs
  - One Toshiba steam turbine
  - 65+% carbon capture
    ~800 lb_{CO2}/MWh_{net} or ~550 lb_{CO2}/MWh_{gross}
  - 582 MW peak and 526 MW on syngas
  - Heat rate 12,150 Btu/kWh_{NET}

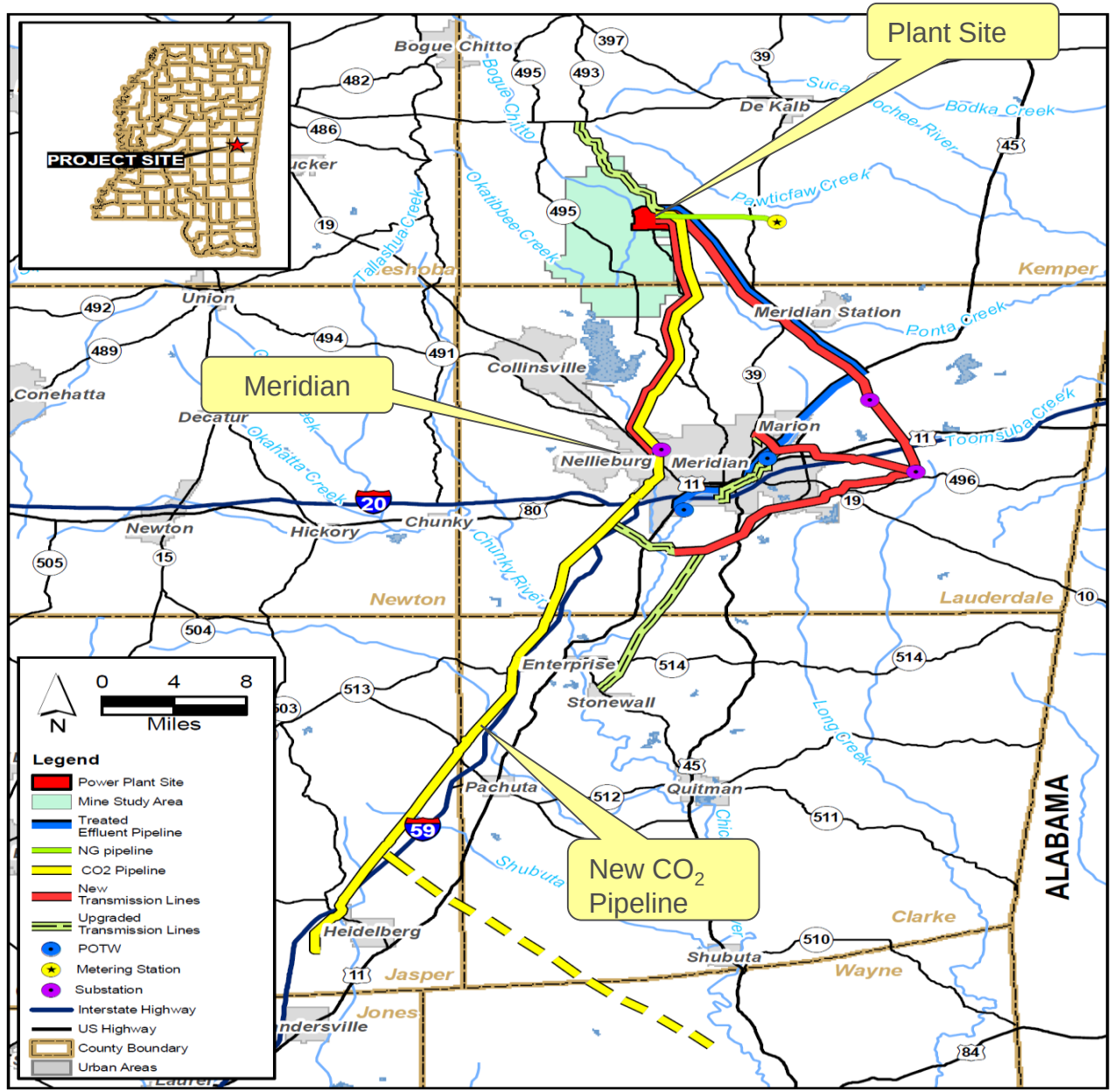
- **Byproducts (TPY)**
  - ~3,800,000 - CO_2 used for EOR
  - ~150,000 - sulfuric acid
  - ~19,000 – ammonia

Kemper Lignite Composition				
		Average	Min	Max
Heat Content	btu/lb	5,290	4,765	5,870
Moisture	%	45.5	42	50
Ash	%	12.0	8.6	17
Sulfur	%	1.0	0.35	1.7



Kemper Project Map

- ~70 miles transmission
- ~60 miles CO_2 pipeline (for EOR)
- ~5 miles natural gas pipeline
- ~30 miles treated effluent line

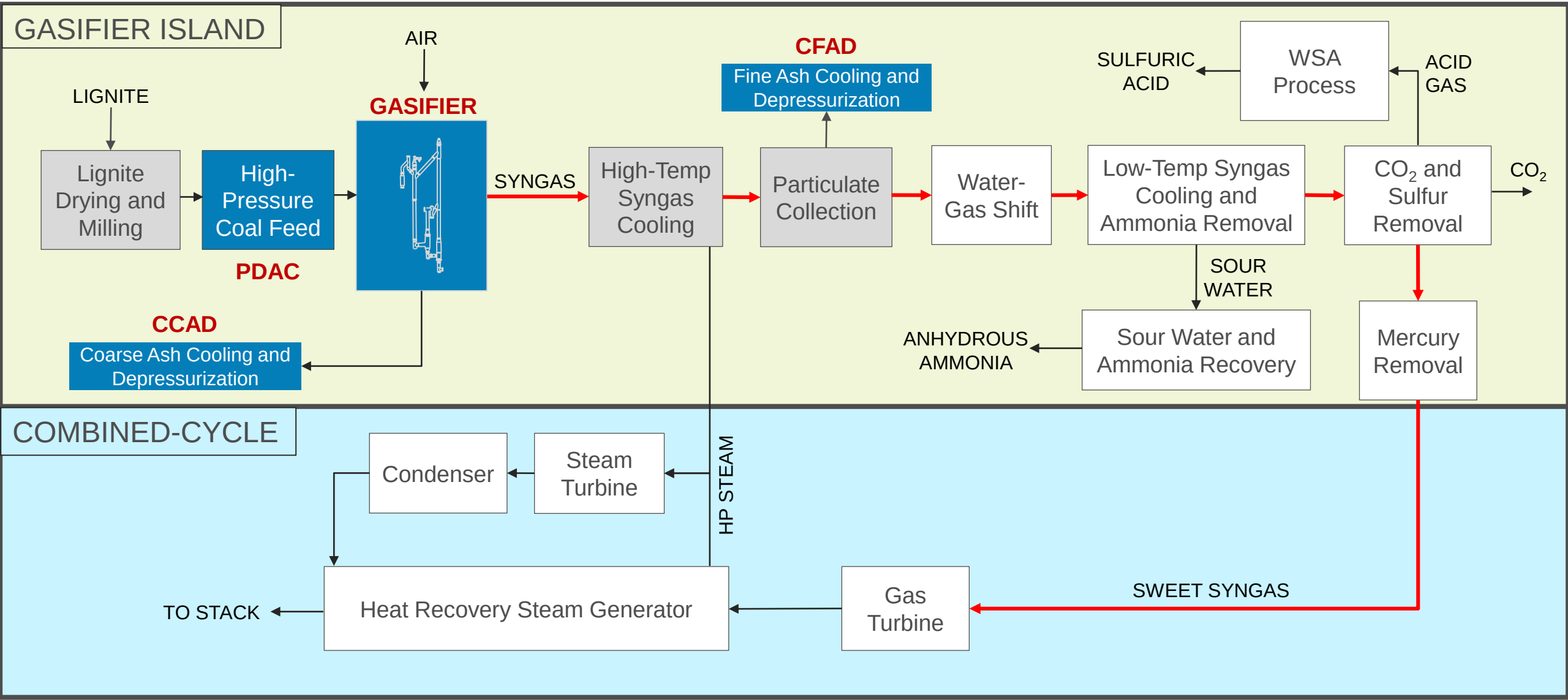


Kemper Block Flow Diagram

Patented by Southern Company

Tested at PSDF (Commercially Available)

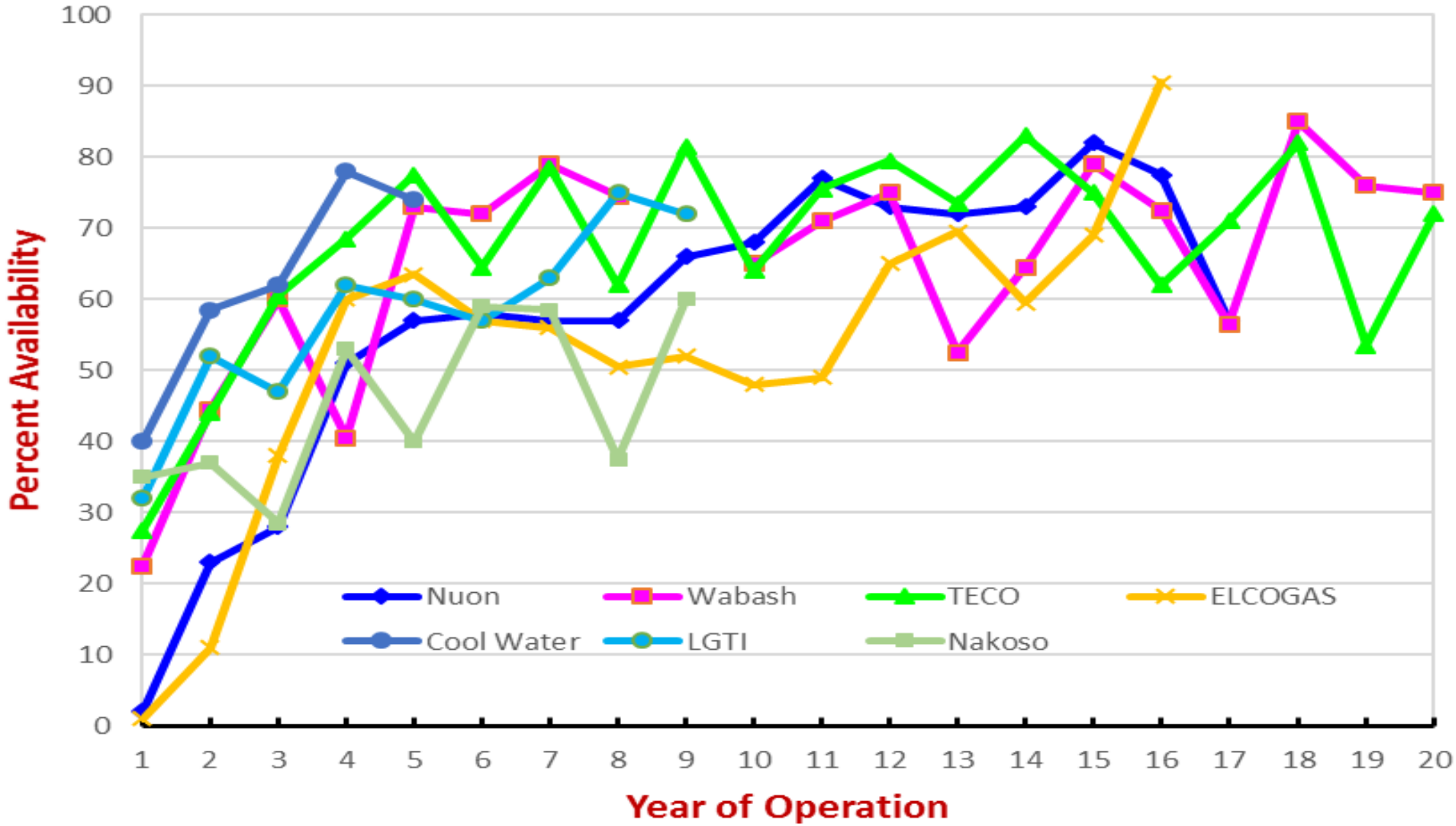
Not Tested at PSDF (Commercially Available)

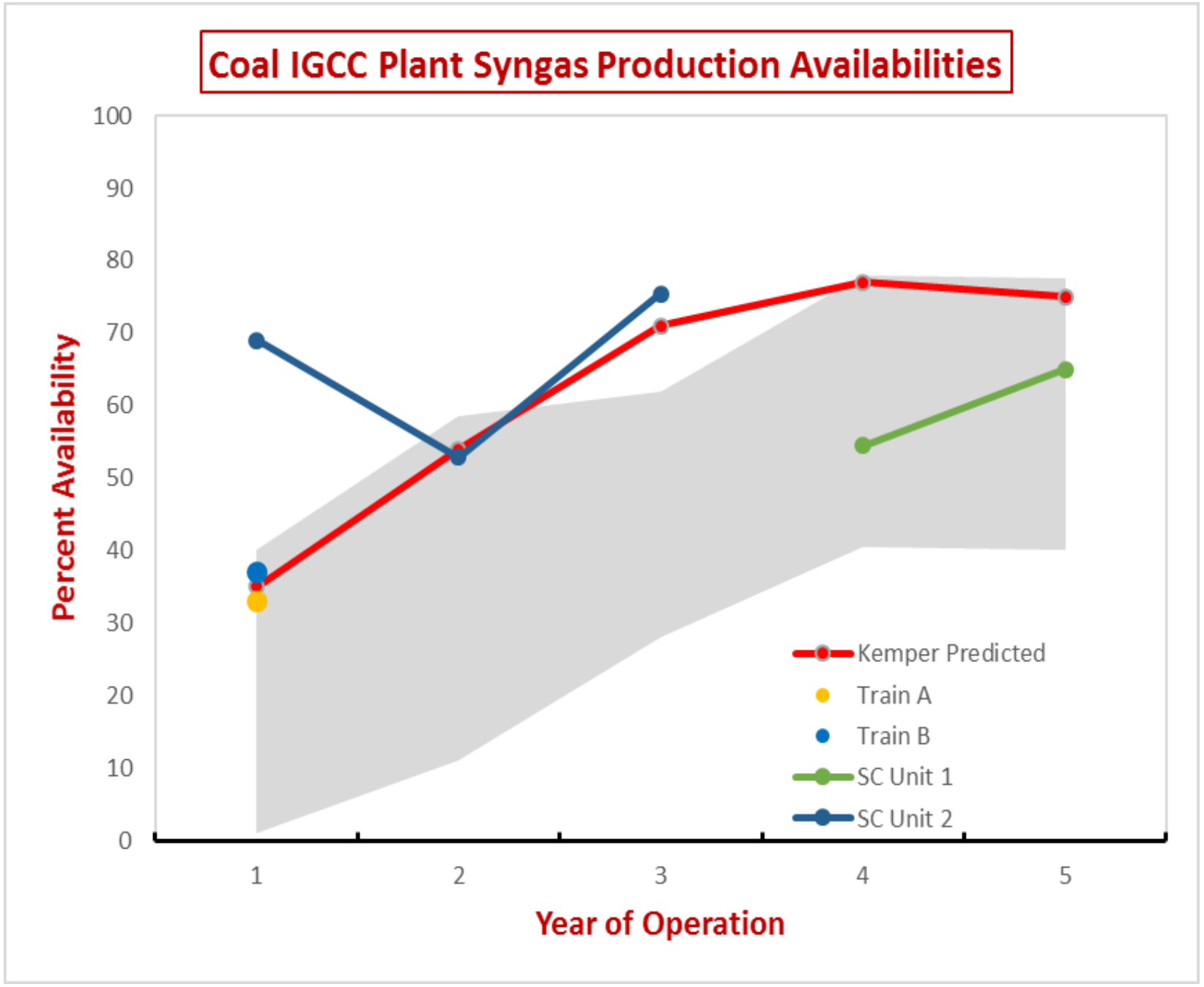


Operational Summary

- Achieved fully integrated operation of entire IGCC
  - Both CTs produced power with syngas
  - Steam turbine produced power with superheated steam from the syngas coolers
  - On spec production of byproducts – CO_2, anhydrous ammonia, sulfuric acid
- First-of-a-kind commercial TRIG™ gasification system
  - Availability as good or better than other gasification technologies during first year operation
  - 90% gasifier availability
- Availability following expected availability ramp
- Kemper operation suspended primarily due to dramatic decrease in price and forecast for natural gas
  - Natural gas prices and forecast decreased 60-70% since 2010 project approval

Coal IGCC Plant Syngas Production Availabilities





TRIG Advantages

- No internal burners / fuel injectors
- Longer refractory life
- Dry ash – no molten slag or corrosive / erosive blackwater system
- Higher carbon conversion → less tar → less syngas cooler fouling

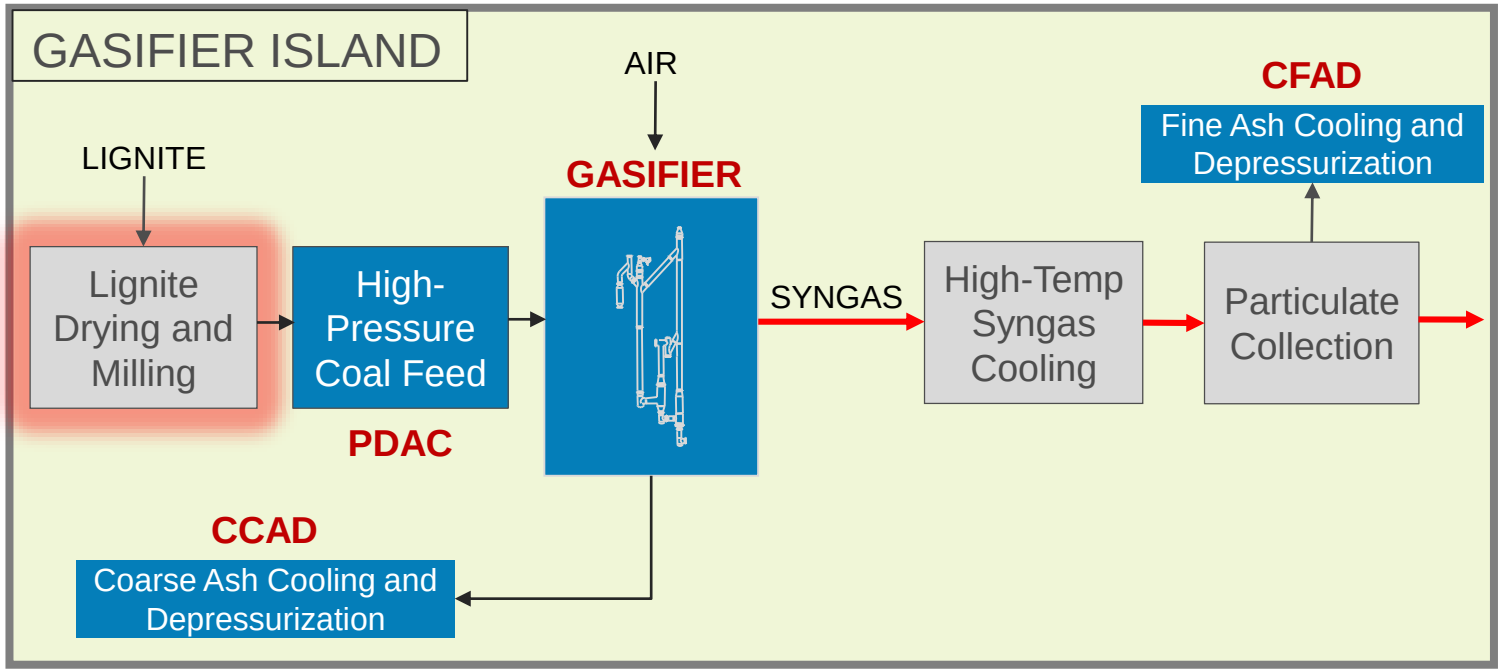
Key Operating Statistics

- Gasifier operation
  - 224 total days of lignite gasification
  - Achieved 100% gasifier design coal feed capacity
- Syngas cleanup/emissions
  - Met all environmental permit requirements
  - Achieved design 65% CO_2 capture and transport for Enhanced Oil Recovery (EOR)
  - On spec production of CO_2, ammonia and sulfuric acid
- CT operation on syngas
  - 73% capacity achieved at 170 MW
    - *Siemens limited CT capacity on syngas to 70% until June 2017, then increased to 80%*
  - 164,900 MWh generated with syngas

Remaining Challenges

Inconsistent raw coal quality

- Frequently outside design range for both moisture and particle size
- Modifications in May-June 2017 improved reliability
- Before modifications, sustained 80% gasifier coal feed capacity with three dryers
- After modifications, sustained 80% gasifier coal feed capacity with two dryers.
- Additional changes were being developed and implemented



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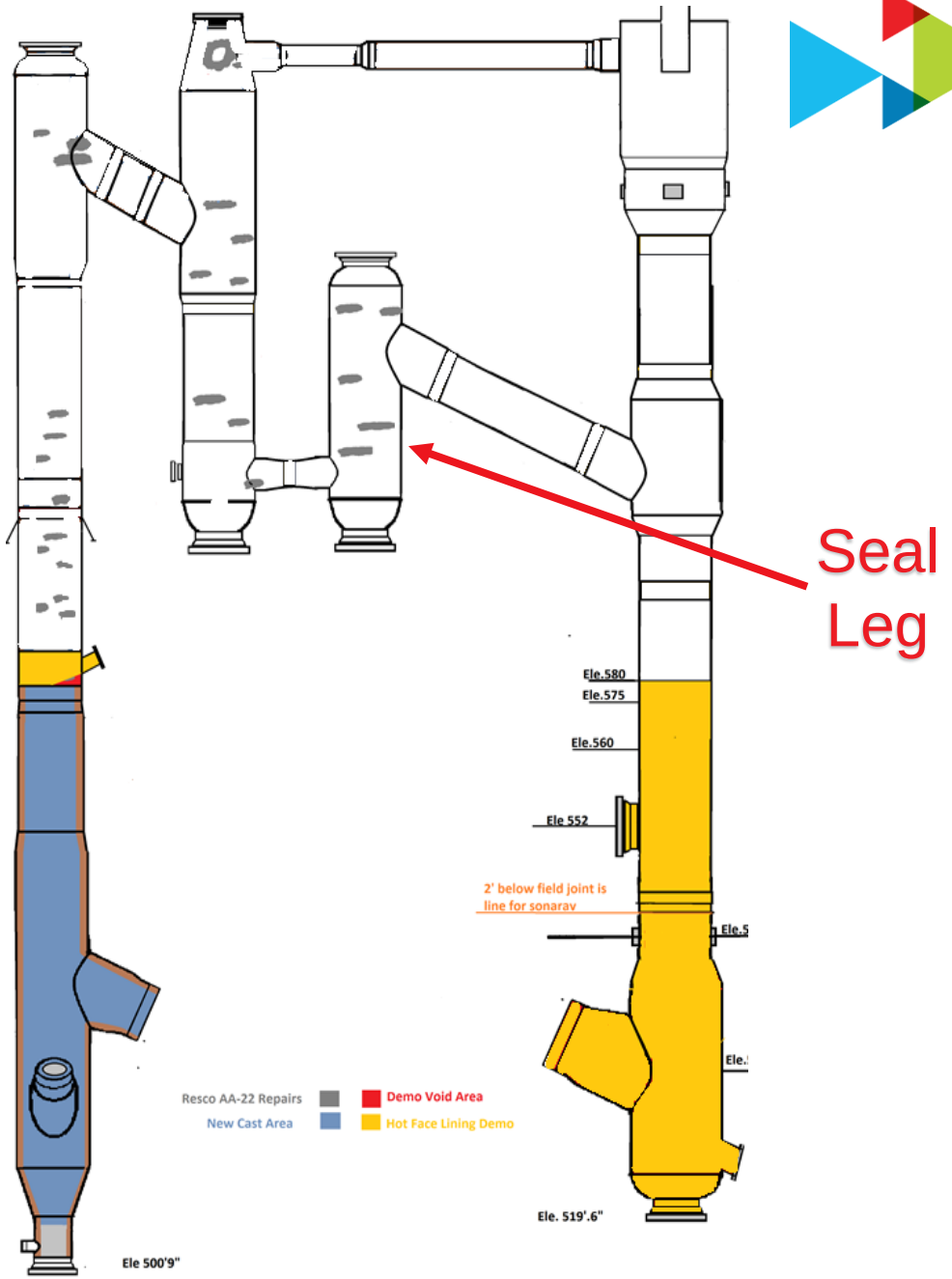
Remaining Challenges

Refractory replacement in the gasifier seal leg outlet

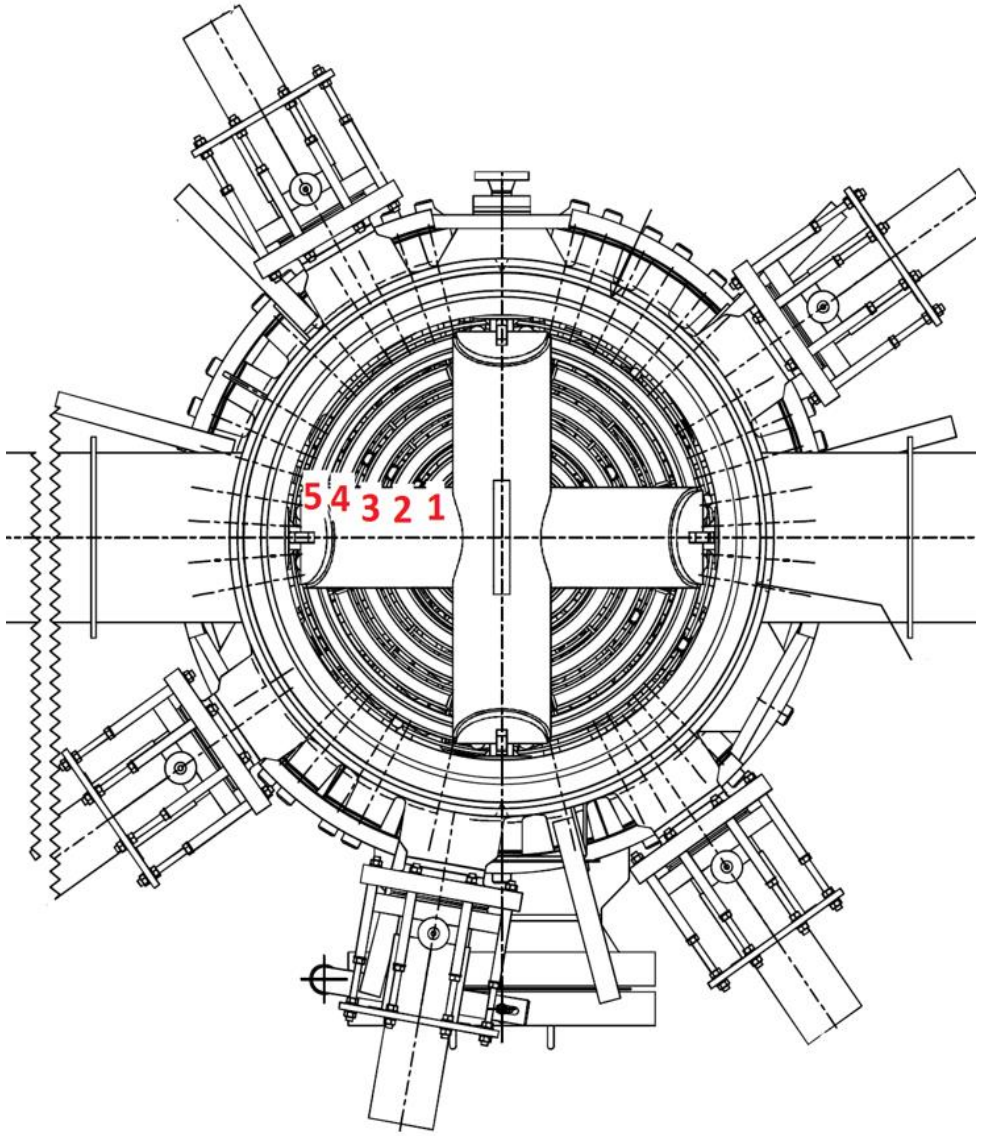
- Refractory improperly installed in shop - experienced significant and uncharacteristic spalling during drying, but construction schedule prevented refractory replacement
- Bottom sections replaced in situ during commissioning and worked well thereafter
- Upper section spalled from the seal leg, blocking ash removal and requiring periodic clean-out
- Refractory replacement scheduled for upcoming October 2017 outage would have eliminated significant spalling



Remaining Challenges

Syngas cooler superheater tube leaks

- Numerous leaks developed at tube supports of Coil 5 on multiple superheaters
- Finite element analysis revealed insufficient tube thickness/design margin at tube support weld connections
- All Coil 5 tubes plugged in each train's Superheater II prior to June 2017
  - Sufficient heat transfer area remaining for full coal feed rates because less tube fouling than expected
  - Inner coils likely under less overall stress than Coil 5 per engineering evaluations
- No additional tube failures, but insufficient operating time to prove conclusively reliable



Remaining Challenges

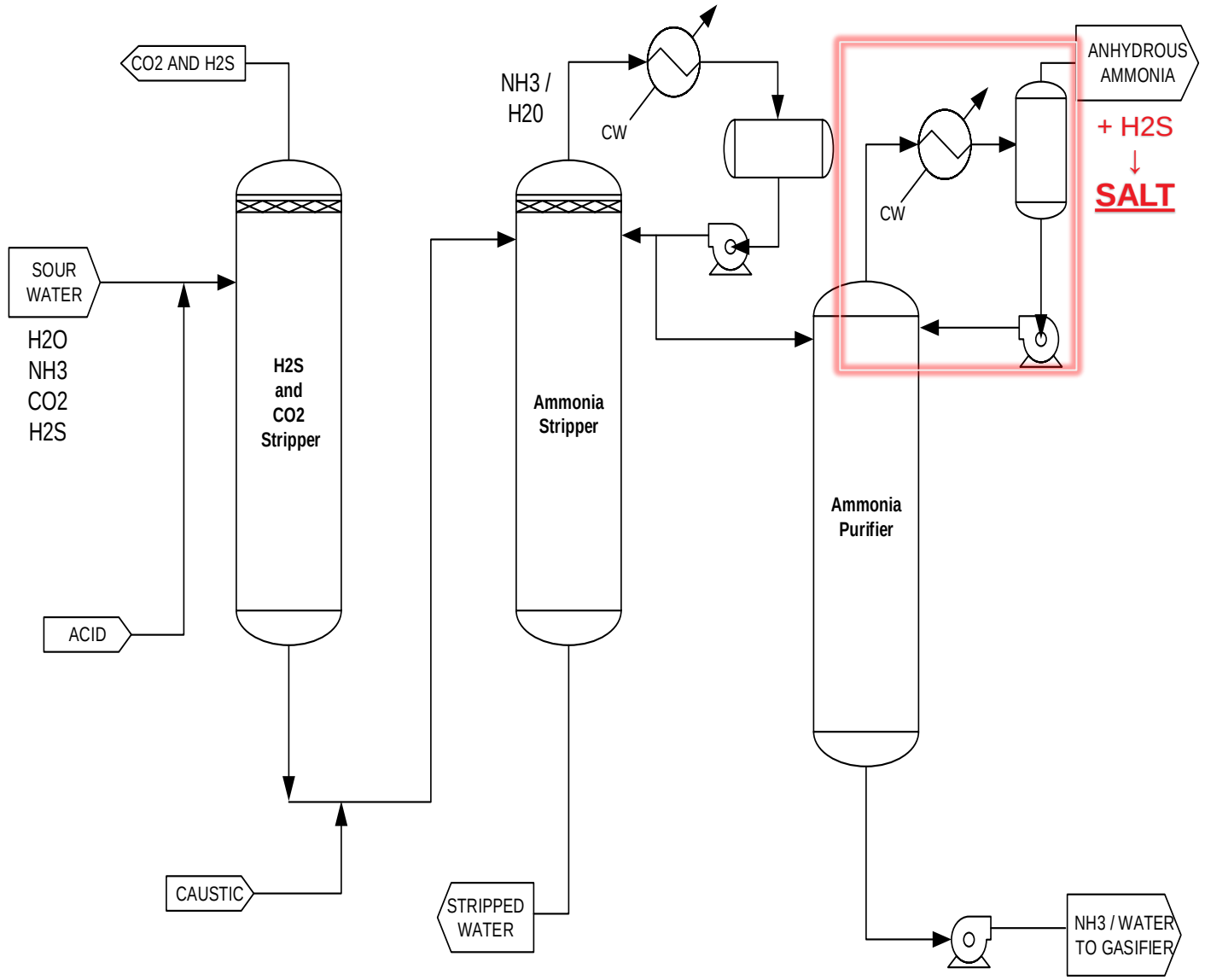
Excess sour water production from syngas scrubbers

- Damage to scrubber internals and design of chimney trays allowed excessive water bypassing to sour water system
- Sour water system overwhelmed with two gasifier trains at higher coal feed rates
- Chimney tray redesign scheduled for October outage would have resolved this issue

Remaining Challenges

Salt formation in the Sour Water system

- High sour water pH preventing adequate separation of ammonia, CO_2 and H_2S
- Ammonium bisulfide salts forming in ammonia purification equipment, limiting capacity and reliability at high coal feed rates
- Acid and caustic injection changes in progress to increase pH control and improve separation



Conclusions

- Core TRIG™ technology successfully demonstrated at commercial scale
  - Operated at 100% of coal feed design
  - Produced syngas suitable for power generation in the CT

- Kemper IGCC demonstrated with dual-train operation
  - Modifications required to sustain operation of both trains simultaneously and to achieve the long-term availability ramp

- Fuel price differential between natural gas and lignite was the primary reason for suspension of operations prior to making the identified modifications for sustained dual-train operation

Next Steps

- Evaluate and develop best practices and lessons learned from design, construction, startup and operations of the Kemper IGCC project
- Continue supporting DOE mission to advance clean coal and carbon capture technologies
  - Commissioning report with lessons learned
  - Final Full Project report with lessons learned
  - TRIG™ reference plant with expected capital and operating costs for next-generation TRIG™ IGCC
- Continue supporting development of clean coal technologies to ensure they are ready to serve energy needs where fuel costs and carbon capture credits make them economically competitive

Questions?