Scaleup and Commercialization of Warm Syngas Cleanup Technology with Carbon Capture and Storage

2010 Gasification Technology Conference, Washington, D.C.

Raghubir Gupta, Aqil Jamal,
Brian Turk, and Markus Lesemann

Center for Energy Technology
RTI International
Research Triangle Park, NC

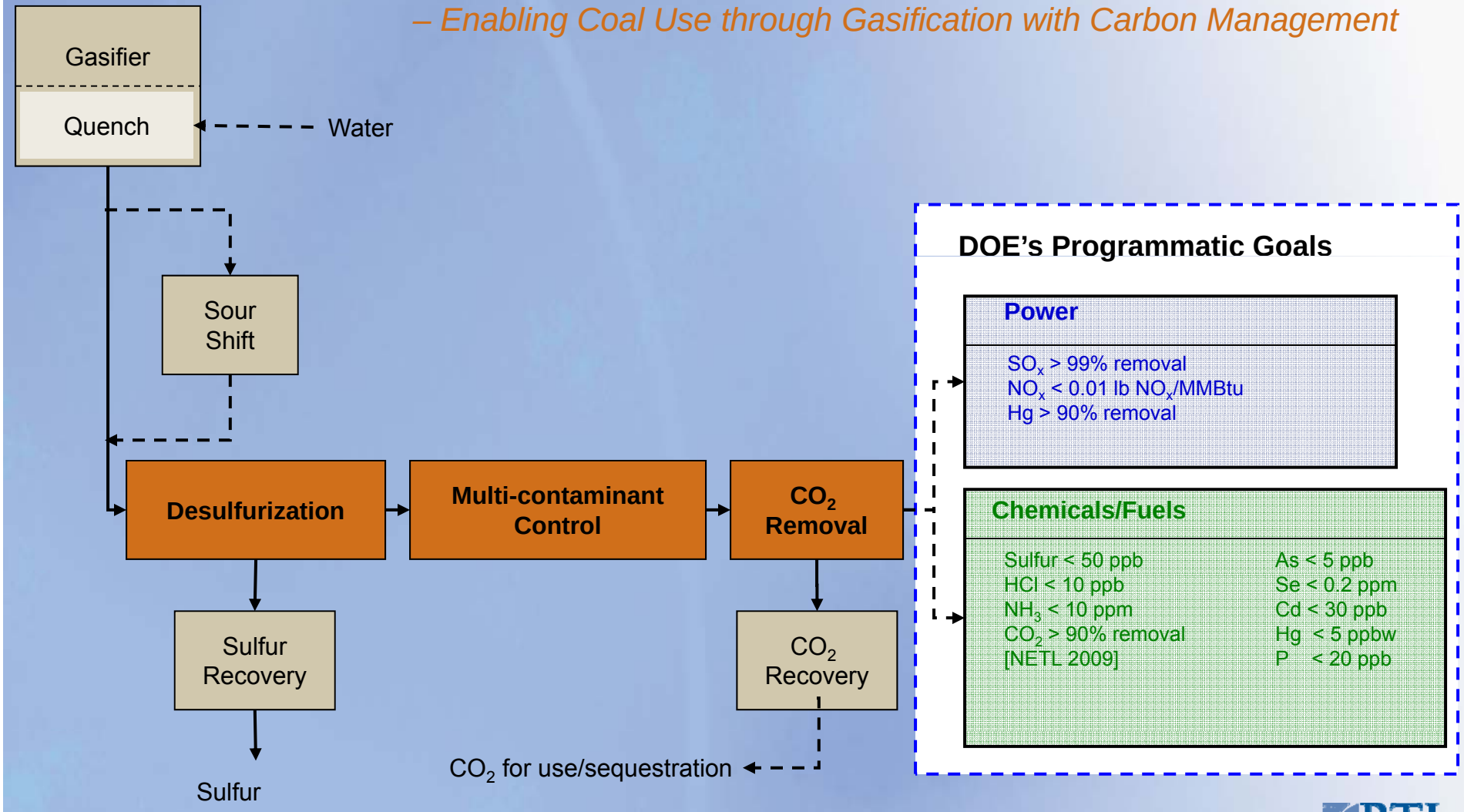
www.rti.org

RTI International

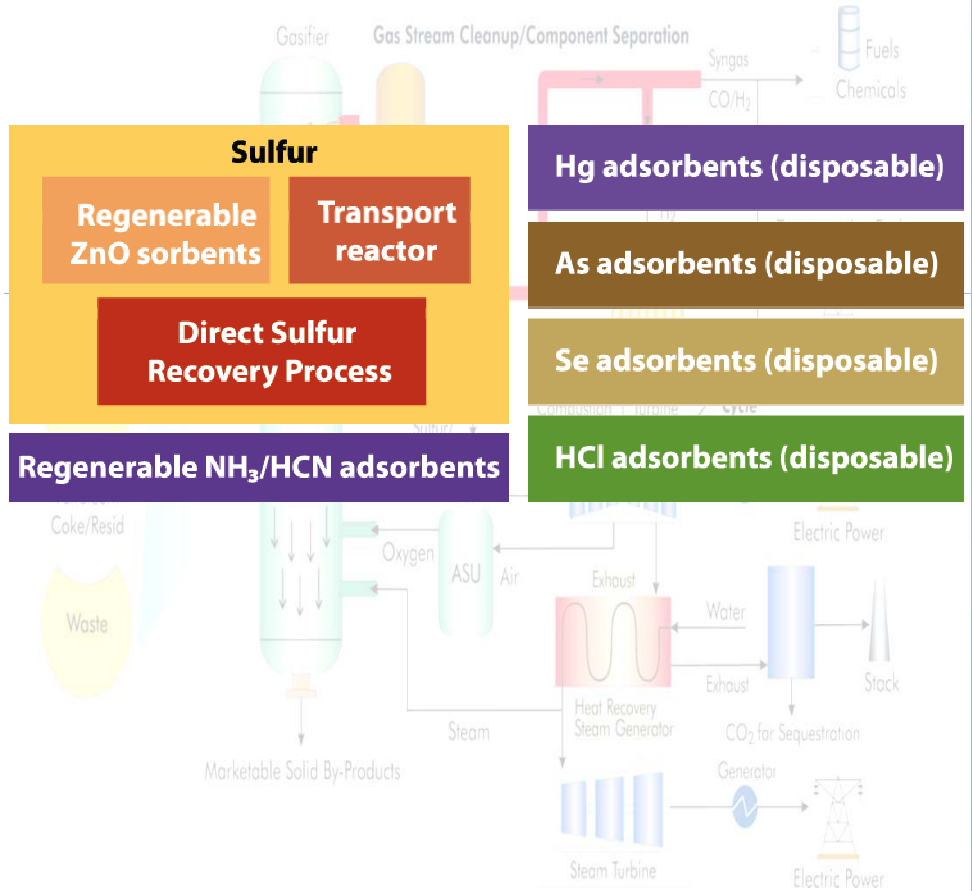
- Established 1958 as collaboration between state government, area universities and business leaders
- Mission: to improve the human condition by turning knowledge into practice
- One of the world's leading research institutes
- FY2009 Research revenue: $717.9 million
- Staff : 2,866

Syngas Cleanup

– Enabling Coal Use through Gasification with Carbon Management

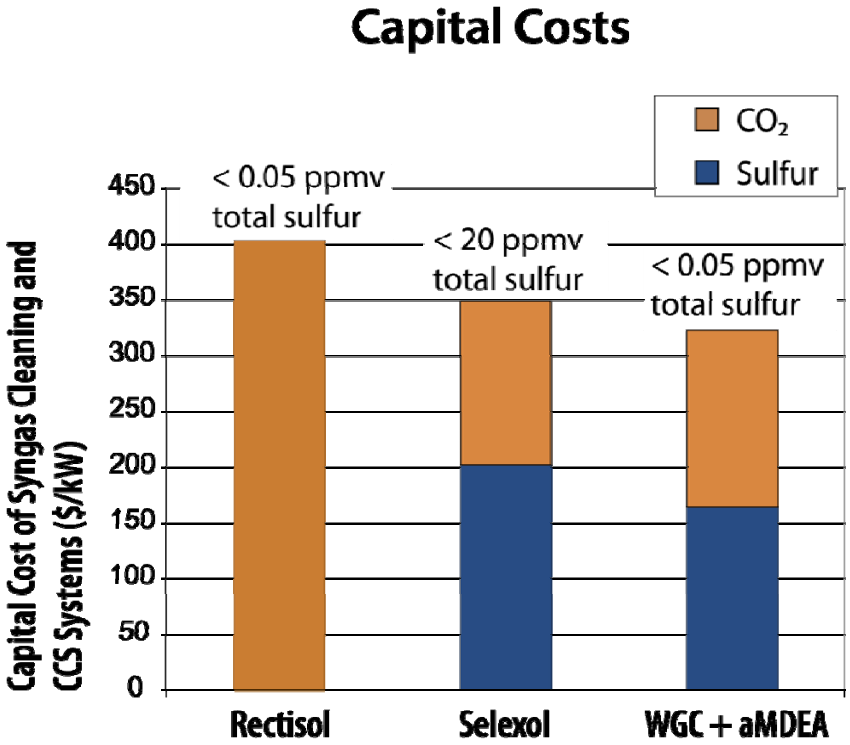


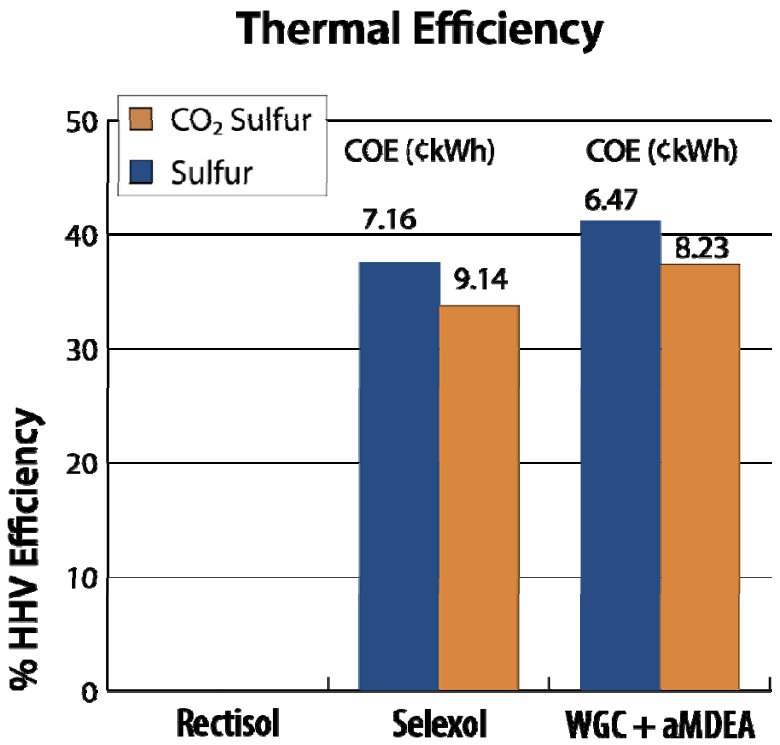
RTI Warm Syngas Clean-up Technology Platform



- Syngas contaminant removal at elevated temperatures
  - Sulfur
  - Heavy metals (Hg, As, Se)
  - HCl, NH_3, HCN
- Unique Features
  - Operating temperatures >450ºF
  - Pressure independent
  - Effective for both H_2S and COS
- Fully compatible with conventional and warm CO_2 capture
- Flexible modular approach meets
  - Power specifications
  - Chemical production (methanol, SNG, FT,…) specifications

Comparison of Cost and Performance of Various Syngas Cleanup + CCS Options

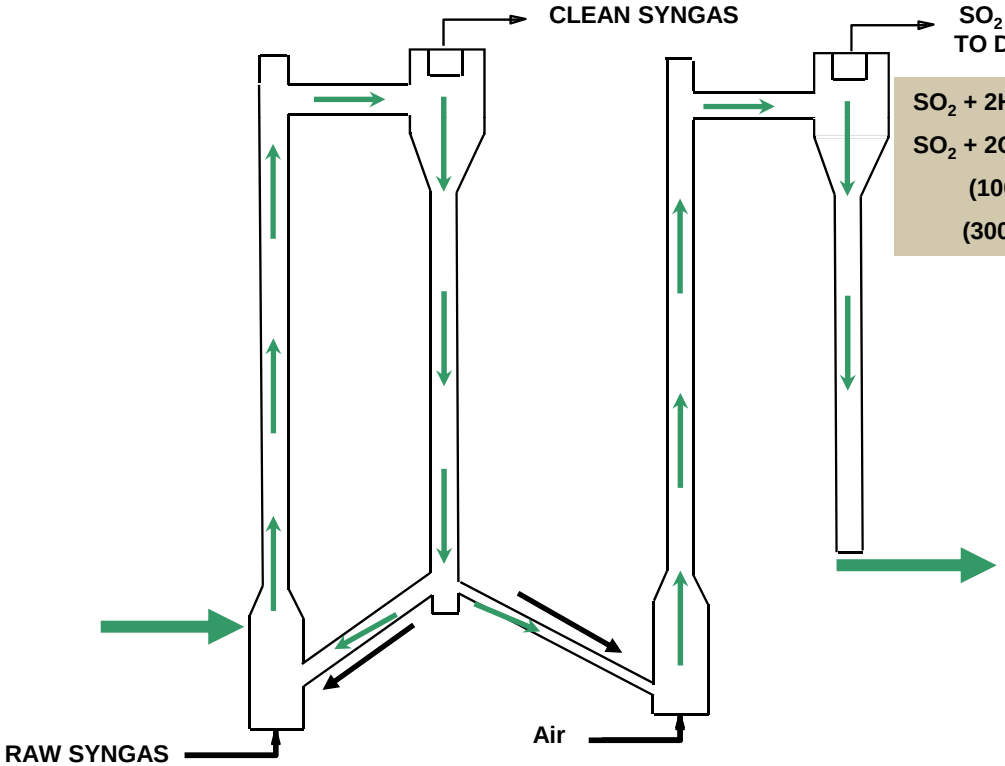




Transport Desulfurization Reactor System

$ZnO + H_2S \rightarrow ZnS + H_2O$
$ZnO + COS \rightarrow ZnS + CO_2$
(600 -1000ºF)
(300-600 psig)

$ZnS + 3/2O_2 \rightarrow ZnO + SO_2$
(1200-1400ºF)
(300-600 psig)



High Temperature Desulfuization Process (HTDP)

Desulfurization Sorbent Characteristics

- ZnO supported on zinc aluminate
  - High attrition resistance (≥FCC catalyst)
  - Inert support (chemical stability)
- Unique highly dispersed ZnO nanostructures with grain size <50 nm
  - High reactivity (short residence time in the reactor)
- Produced on commercial scale by spray drying by Süd-Chemie
  - Average particle size: 75 µm
  - Hydrodynamic properties similar to FCC Catalyst
- Covered by US/International patents
- Won 2004 R&D 100 Award

RTI INTERNATIONAL

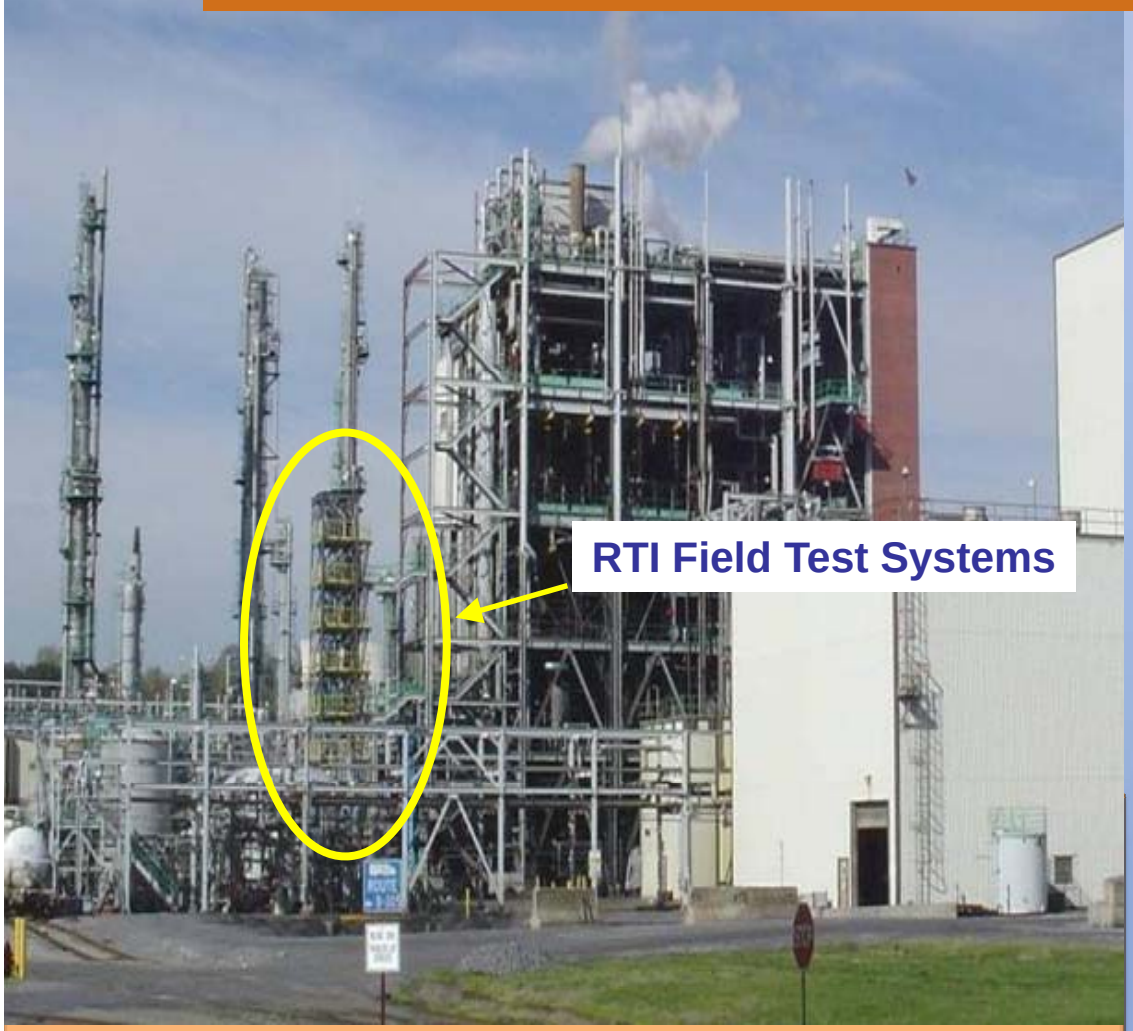
Multicontaminant Control Removal

Ammonia and trace metal skid for testing at Eastman

- Removal of contaminants other than sulfur from syngas under high-pressure, high-temperature conditions
- Target contaminants: Hg, As, Cd, Se, Ammonia, HCN
- Test program
  - Extensive sorbent screening at RTI
  - Capacity tests on selected sorbents
  - Evaluation of potential process integration issues
    - Effect of S on sorbent effectiveness for other contaminants
    - Multicontaminant effects

RTI INTERNATIONAL

Pilot Plant Phase at Eastman Chemical Company with Coal-derived Syngas



Eastman Gasification Plant

EASTMAN

- Commercial production of desulfurization sorbent (10,000 lbs by Süd-Chemie)
- High Temperature Desulfurization Process (HTDP)
  - >99.9 % removal of both H_2S and COS simultaneously
  - <5 ppmv effluent sulfur achieved independent of operating pressure
  - >3,000 hours of operation
  - ~ 60% of typical attrition in commercial FCC systems
- Direct Sulfur Recovery Process (DSRP)
  - >99.8% SO_2 conversion to elemental sulfur
- 96% ammonia removal
- 90% mercury and arsenic removal

RTI INTERNATIONAL

50 MW Pre-Commercial Syngas Cleaning — Objectives

Tampa Electric Company's Polk Power Station

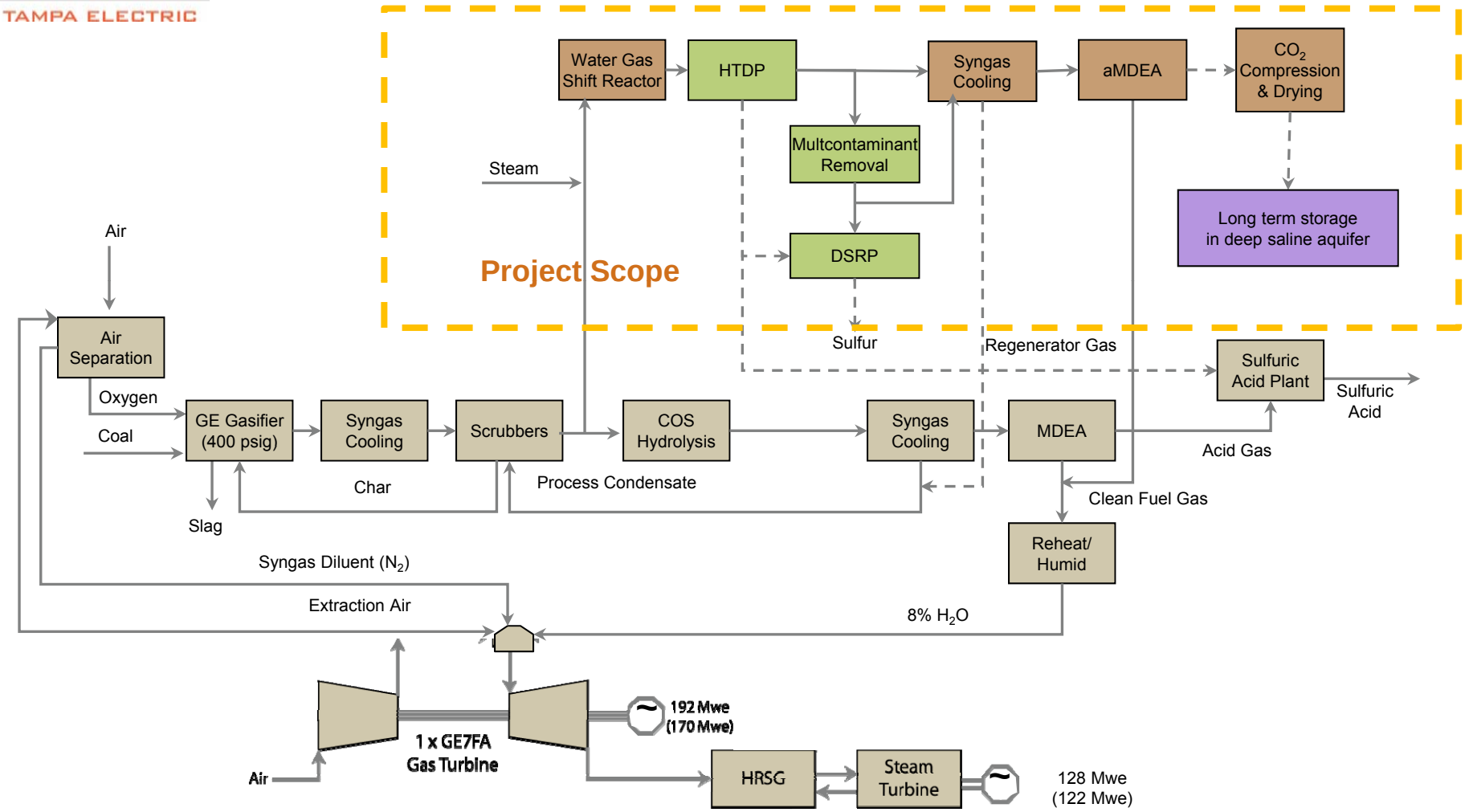
- Warm Syngas Clean-up
  - Design, construct, commission, and operate a warm syngas cleaning demonstration system
  - Establish relevant commercial operating experience
  - Establish RAM (reliability, availability and maintenance) targets
  - Mitigate design and scale up risk for commercial plant
- Carbon Capture and Sequestration
  - Sequester 300,000 tons of CO_2/year
  - Use of conventional capture technology (activated amine)

Tampa Electric Polk Power Station

Five Generating Units – Rural Location

- Unit 1 IGCC:
  - 320 MW gross generation.
  - DOE Clean Coal Technology co-funding $120M.
  - In service 1996.
  - World Leader in power generation from syngas.
  - Long history of partnership with DOE including technology demonstration and information sharing.
  - Hosted over 5,000 visitors from all over the world.
- Unit 2, 3, 4 & 5 Simple Cycle CT, Peaking, 150+ MW each
- Total site over 4,000 acres (previously mined for phosphate.)

Integration of Syngas Cleaning and CCS Systems at Tampa Electric



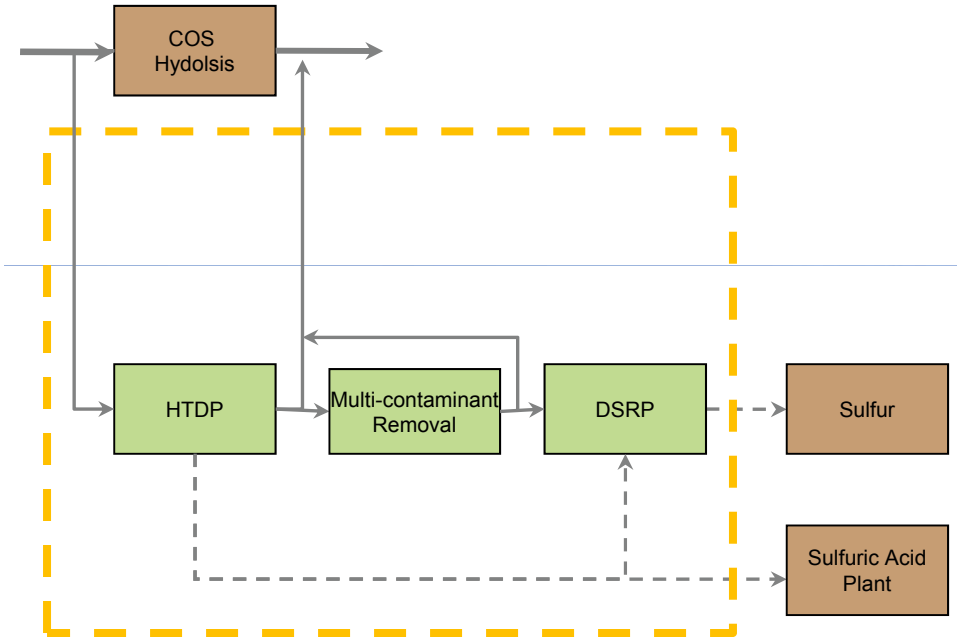
Specific Project Goals

Technology	Size	Operation	Performance
HTDP	50 MWe*	8,000 h	Total sulfur <10 ppmv
DSRP	5 tpd sulfur (25% of HTDP off-gas)	8,000 h	>95% SO_2 Conversion
Trace Contaminants (Hg, As, and Se)	5 MWe	8,000 h	>90% Removal
CO_2 Capture and Sequestration	300,000 tons CO_2/year	8,000 h	>90 % removal

* 50 MWe is equivalent to 2,000,000 scfh of syngas on dry basis (about 20-30% of TECO's syngas)

13

Design Status for Warm Syngas Cleanup System

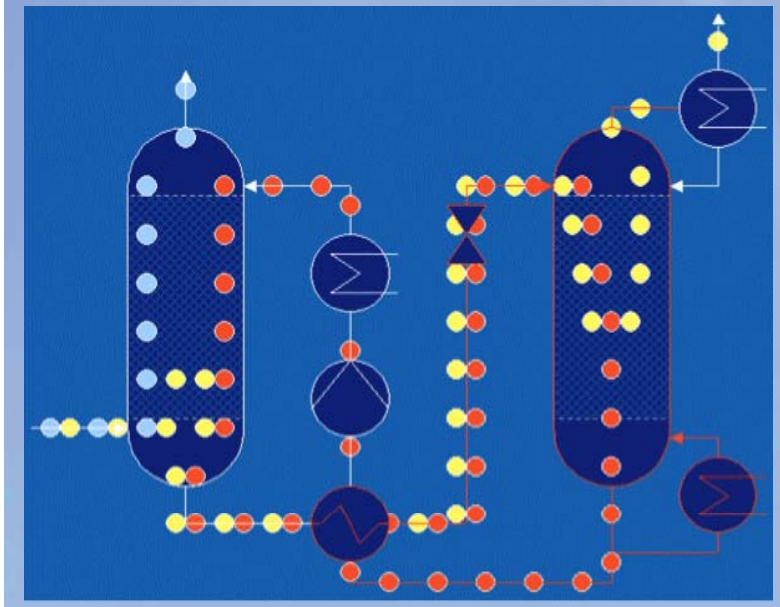


Warm Syngas Cleanup System for 50 MW Project

- Pre-FEED package (for warm gas cleanup system) complete
  - Process flow diagrams
  - Heat and mass balances
  - Preliminary P&IDs
  - Equipment list
  - Preliminary Process Hazard Analysis
  - Risk analysis
- Cost estimate in progress
  - Vendor quotes for equipment being collected

RTI INTERNATIONAL

CO_2 Capture: BASF aMDEA® Process



- Higher absorption capacity
- Higher absorption kinetics
- Lower energy requirement for regeneration
- No degradation
- Chemically and thermally stable
- Non-corrosive nature
- Non-toxic and readily biodegradable

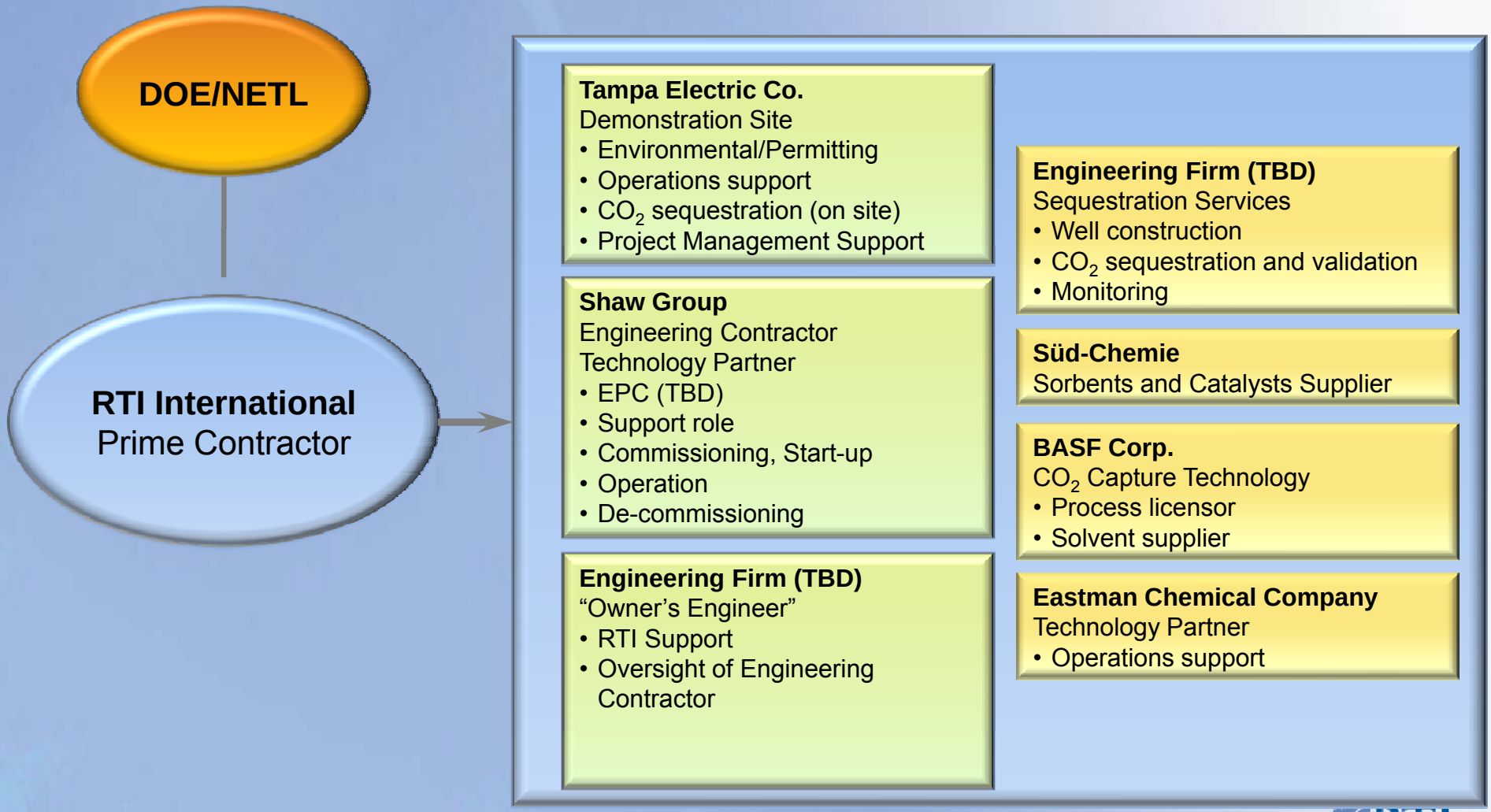
Feed Gas / Liquid
CO_2, H_2S
aMDEA

Source: BASF

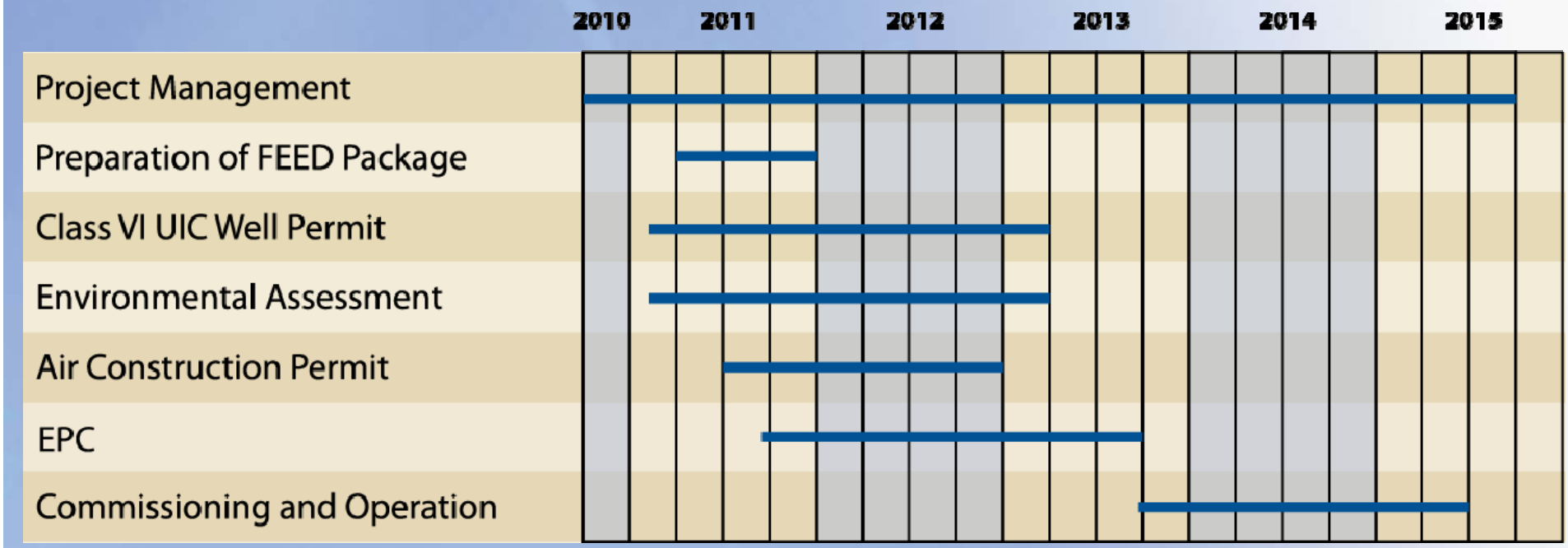
Potential integration options for syngas require effective H_2S removal prior to non-selective H_2S and CO_2 removal with solvent

Integration with warm syngas cleanup results in lowest Capex and Opex because of reductions in equipment size and energy consumption in each system

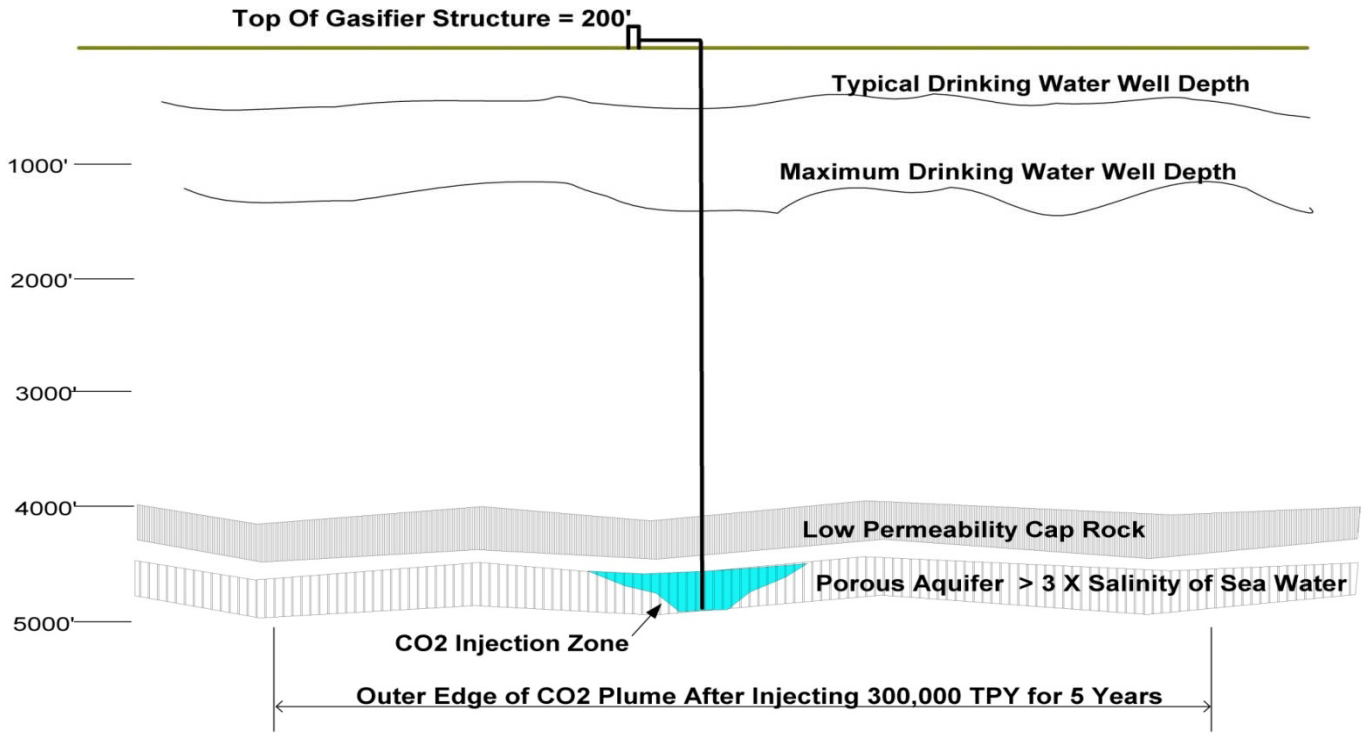
Project Team



Project Schedule



Potential CO_2 Storage at Polk Power Station

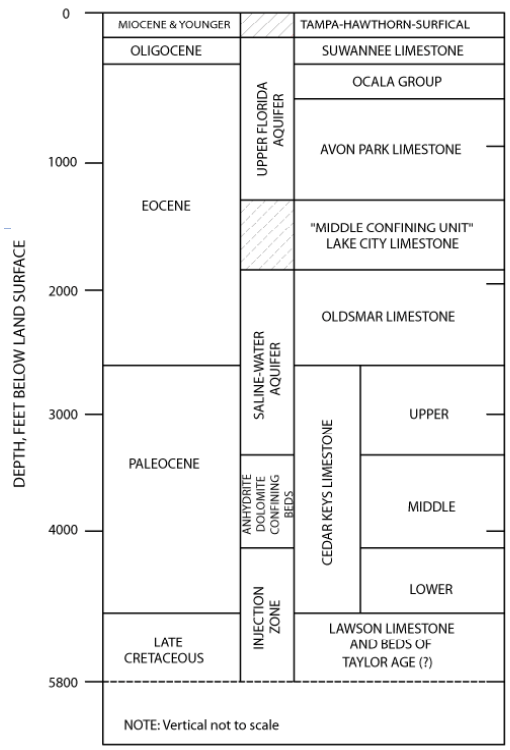


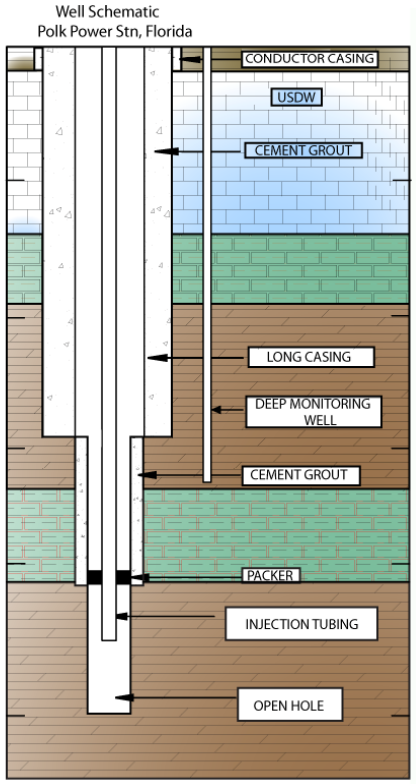
TECO has studied the potential of CO_2 storage at Polk Power Station

- Suitable aquifer exists underneath Polk Power Station
- Size of CO_2 plume would not extend beyond property limits

TECO TAMPA ELECTRIC

Key Critical Design Issues



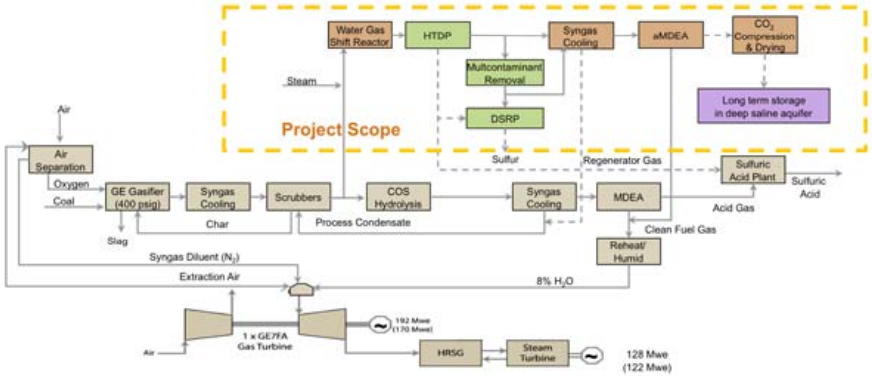


- Permitting for CO_2 sequestration in deep saline aquifer in Florida
- Specification of CO_2 product for sequestration
- Optimization of shift reactor
- Operation of GE 7FA gas turbine on H_2-rich syngas

RTI INTERNATIONAL

Conclusions

- Integration of warm gas cleanup and aMDEA CO_2 capture enables
  - Lower capital cost and higher thermal efficiency for integrated syngas cleaning and CCS
  - Production of chemical grade syngas or H_2
  - Production of high purity CO_2 product for sequestration
- Critical project objectives are to mitigate technology risk for
  - Warm gas cleanup
  - CCS
  - Integration with H_2 turbines
  - Integration with high temperature H_2 membranes



Acknowledgements

- Funding provided by DOE/NETL
- DOE/NETL Technical Team
  - Jenny Tenant
  - Gary Stiegel
  - David Lyons
  - Kanwal Mahajan
  - Sam Tam
  - Pete Rozelle
- Tampa Electric
- Shaw
- BASF
- Eastman Chemical
- Süd Chemie Inc.