Advanced Hydrogen and CO_2 Capture Technology for Sour Syngas

Air Products and Chemicals, Inc.

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Air Products provides technology to capture CO_2 from fossil-fuel-based processes

Hydrogen production from natural gas with CO_2 capture
- For power generation, vehicle fuels, refinery applications

Oxyfuel technology for pulverized coal boilers
- Amenable to both new-build supercritical power plants and retrofitting the large installed base of existing coal-fired assets

CO_2 capture from **gasification**
- Integrated CO_2 capture and acid gas removal

Advanced separation technology
- CO_2 technology using membranes, adsorption, absorption and cryogenic systems

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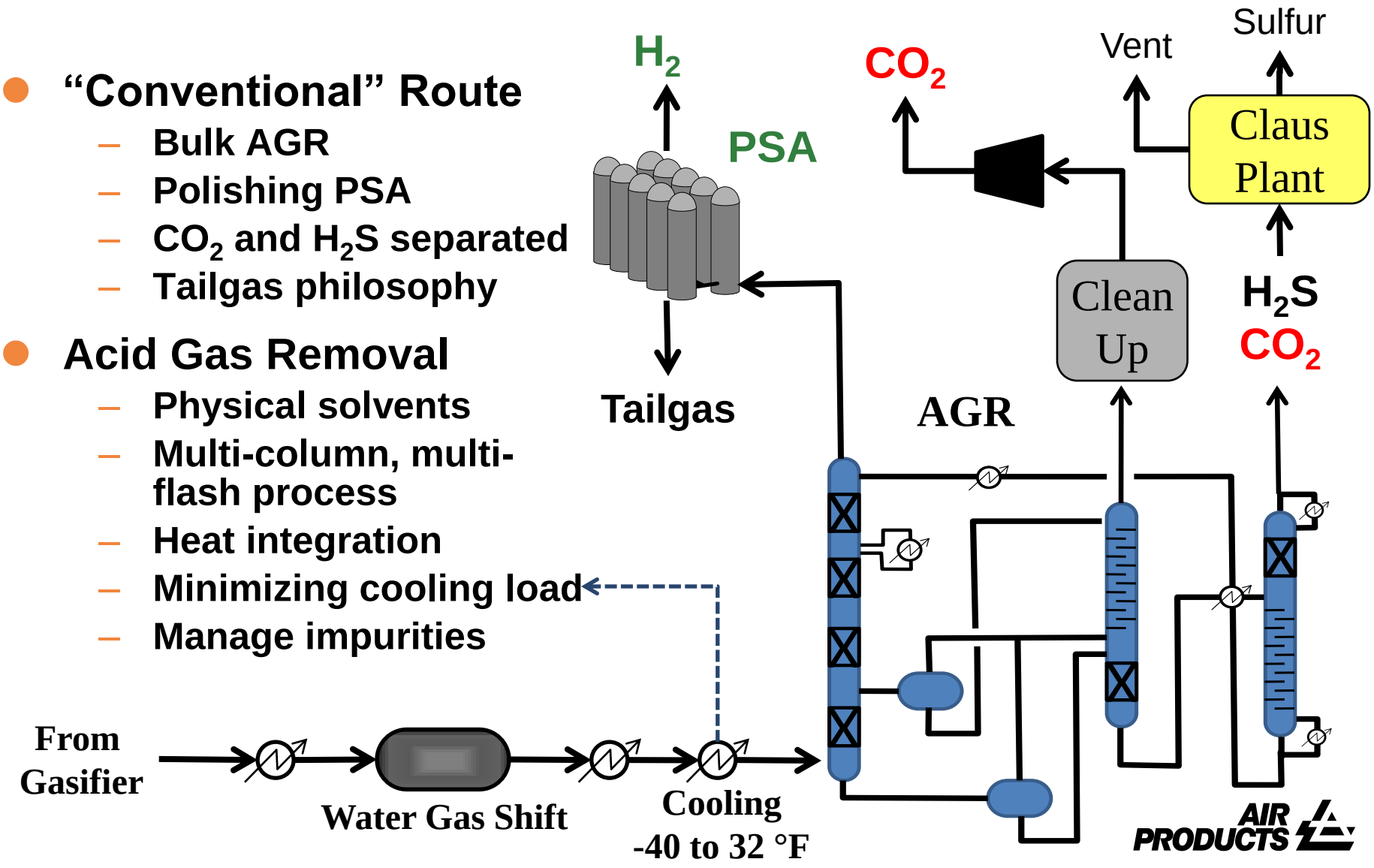
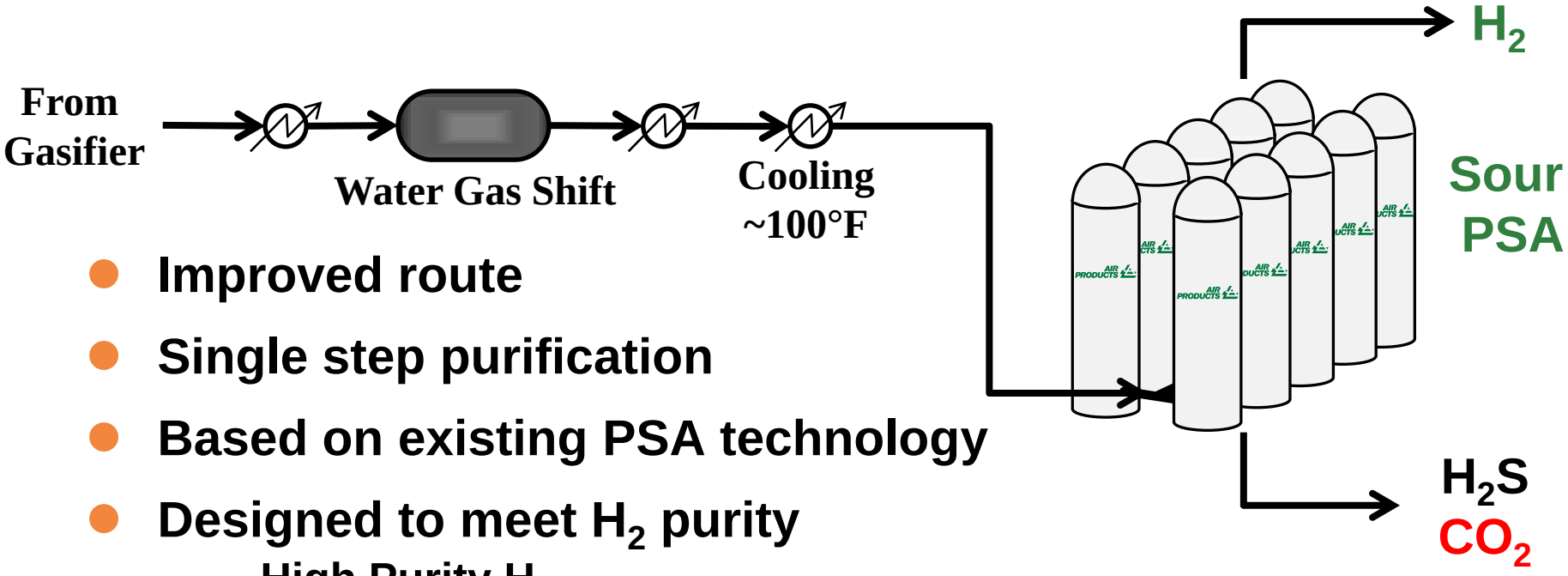
Simplified Gasification Flowsheet for H_2 Production and CO_2 Capture

- "Conventional" Route
  - Bulk AGR
  - Polishing PSA
  - CO_2 and H_2S separated
  - Tailgas philosophy
- Acid Gas Removal
  - Physical solvents
  - Multi-column, multi-flash process
  - Heat integration
  - Minimizing cooling load
  - Manage impurities

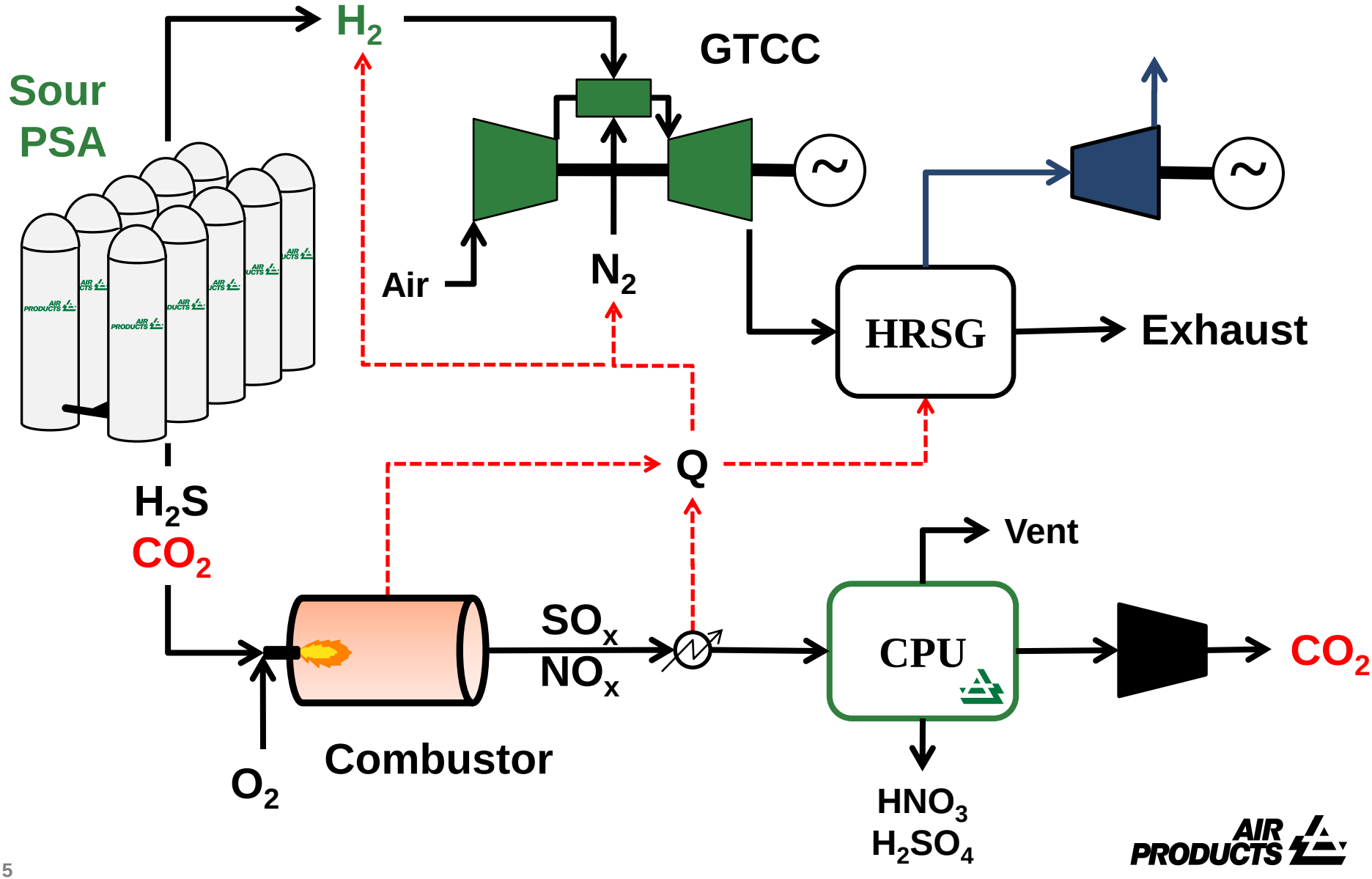


Air Products' "Sour PSA" Technology for H_2 Production and CO_2 Capture



- Improved route
- Single step purification
- Based on existing PSA technology
- Designed to meet H_2 purity
  - High Purity H_2
  - Lower purity for power
  - Sulfur slip of < 3 ppmv, can design for ppb applications
- Reduced capital and operating cost
- Reduced cooling duty, no chilling or refrigeration
- CO_2 and H_2S rejected in tailgas

Tailgas Disposition and Integration



Sour PSA Technology Development

Passive Adsorbent Testing (EERC)

Build Mobile PSA

Coal Testing (EERC)

Alternative Flowsheet Development

Petcoke Testing (EERC)

- Screening by H_2S exposure tests
- Preliminary characterization
- Selection for additional testing

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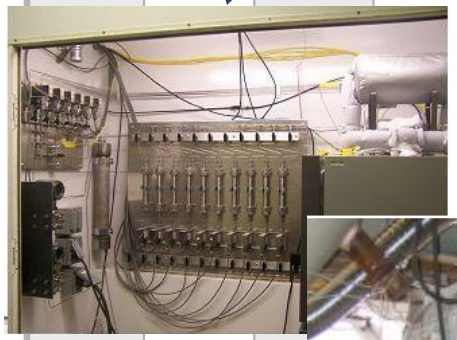
Alternative Flowsheet Development

AERI

supported by Alberta Innovates Energy and Environment Solutions

EERC



- Flexible arrangement: PSA or TSA
- Proof of concept on actual syngas
- Adjust operational parameters
- Advanced characterization
- Enabled rapid model development
- Multiple feedstocks

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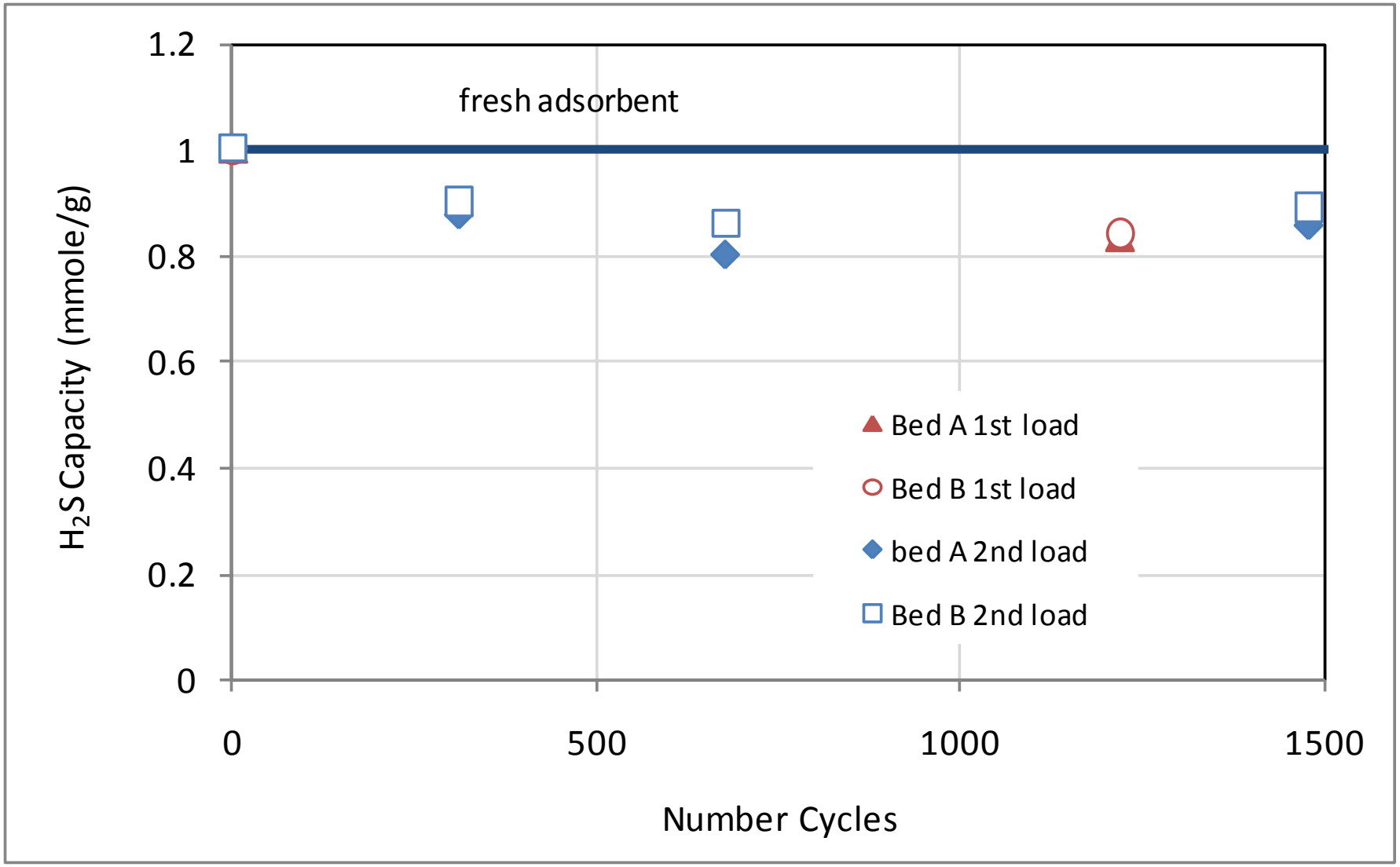
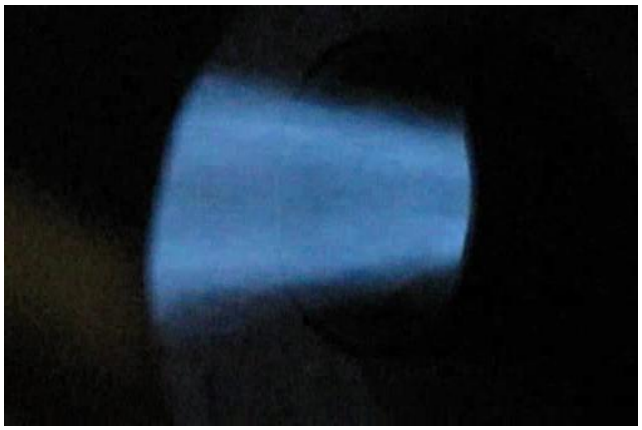
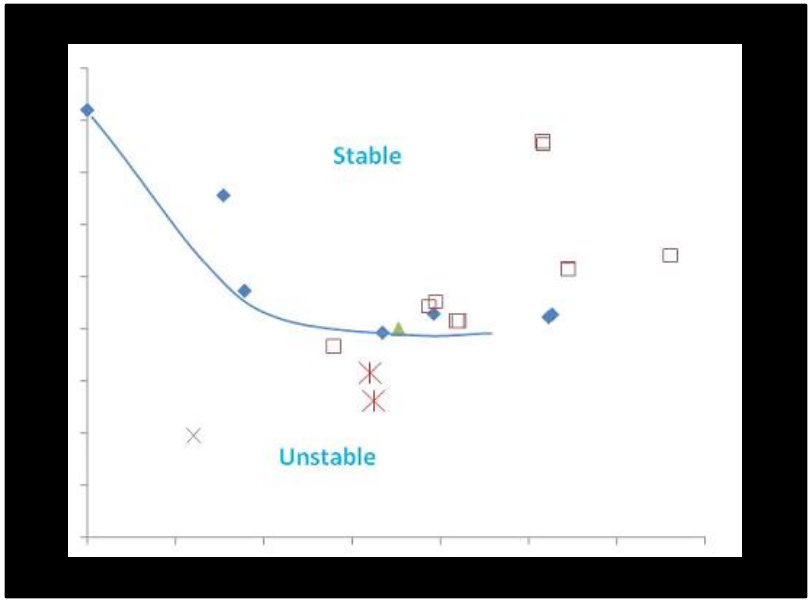
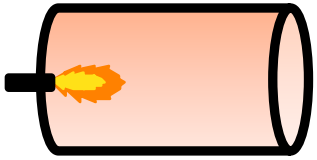
H_2S Capacity Stabilizes



Sour Combustor Development







- **Design Basis**
  - Oxy-Tailgas burner
  - Leverage off oxy-fuel combustion expertise
  - Single or multiple burners
  - Housed in a fired heater or package boiler
- **Status**
  - Designed and tested prototype burners
  - Conducted tests with H_2S laden stream
  - Stability map established
  - Performance mapping underway

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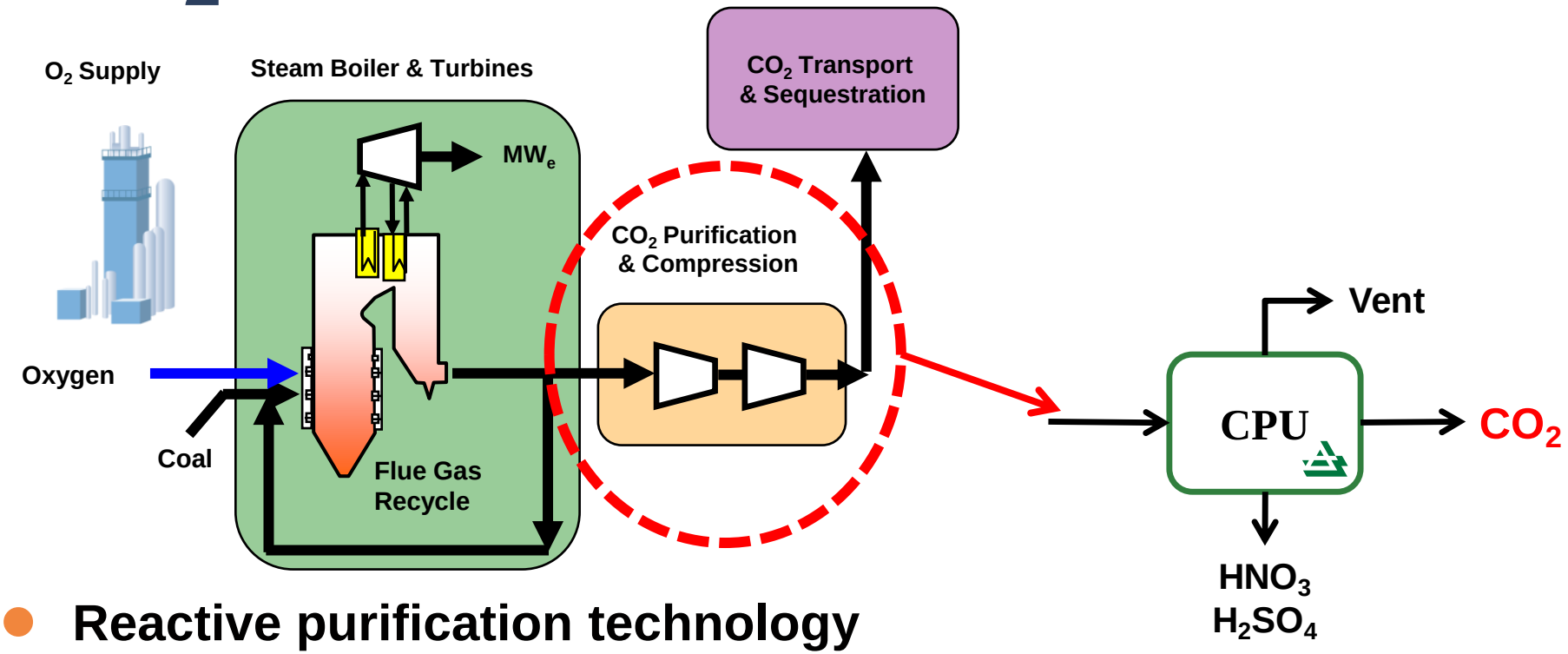
CO_2 Purification Unit



- Reactive purification technology
  - High pressure NOx catalyzed oxidation of SO_2 to H_2SO_4 acid
  - Further purification to remove water and inerts
  - Flowsheets for storage or EOR grade CO_2 applications
- Originally developed for oxycoal power boiler applications
  - Currently in the pilot phase of development
- Extended for sour combustion flue gas

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Techno-Economic Benefits

Case	Units	High Purity H_2		Power	
		Base	Sour PSA	Base	Sour PSA
Petcoke Input	MT/d	4,000	4,000	4,000	4,000
H_2 Produced	kNm^3/hr MMSCFD	305 279	299 273		
Power Produced	MW_{net}			453	473
% CO_2 Captured		~95%	>99%	~90%	~91%
Capital Savings	Millions USD$	106		147	
Operating Savings	Millions USD$/yr	24		2	
Reduction in CO_2 Capture Cost		25.2%		19.7%	

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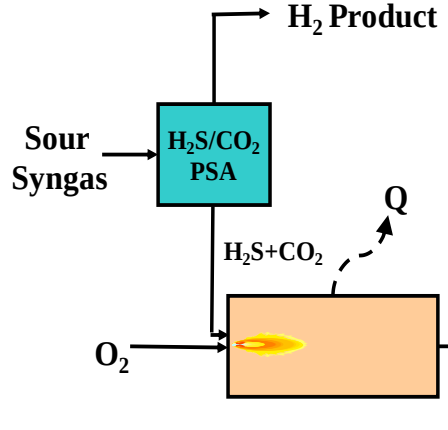
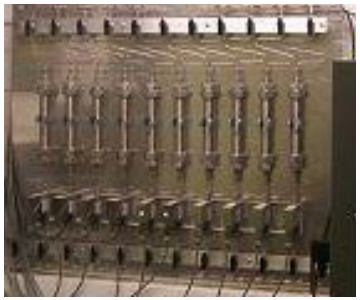
Summary and Conclusions

- Air Products is developing a proprietary low-cost CO_2 capture option for pre-combustion systems
  - Applicable to H_2 and power production
- The technology consists of:
  - H_2 PSA adapted to handle sour syngas
  - Low-BTU oxyfuel burner
  - SO_x, NO_x, and inert removal system developed by Air Products for oxyfuel coal combustion
- Potential advantages over the state of the art:
  - Lower capital and operating costs
    - 25 % reduction in the cost of CO_2 capture
  - Feasible to achieve ~100 % CO_2 capture rate

Scale-Up Pathway





Adsorbent life tests

Lab scale Gasifier / PSA

Design of pilot plant

Pilot

AERI

Calgary, Canada

EERC

Grand Forks, ND

Alberta Innovates Energy and Environment Solutions

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Thank you

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