

Demonstration of CO₂ Capture and Sequestration of Steam Methane Reforming Process Gas for Large-Scale Hydrogen Production

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Air Products and Chemicals

2012 NETL CO₂ Capture Technology Meeting

Pittsburgh, PA

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Agenda

- Air Products Background
- Port Arthur Carbon Capture Project Overview
- Project Technology
- Project Progress
- Future Market

Who Is Air Products?

- Global atmospheric, process and specialty gases, performance materials, equipment and services provider
- Serving industrial, energy, technology and healthcare markets worldwide
- Fortune 500 company
- Operations in over 40 countries
- ~19,000 employees worldwide
- Known for our innovative culture and operational excellence
- Corporate responsibility commitment
- World's largest third party hydrogen supplier
- \$10B+ company in FY11



Project Overview:

State-of-the-Art Carbon Capture from Two Port Arthur, TX SMRs

- American Recovery and Reinvestment Act Funding
 - DOE Funding: \$284 MM
 - DOE Cost Share: 66%
- ~**1 million tons** of CO₂ to be recovered and purified annually starting late 2012
- Valero providing land, rights-of-way, utilities
- AP supplying compressed and purified CO₂ to Denbury for injection into TX oilfields for enhanced oil recovery



Overall Project Objectives



Air Products and Chemicals, Inc.:
Demonstration of CO₂ Capture and
Sequestration of Steam Methane
Reforming Process Gas Used for Large-
Scale Hydrogen Production

- DOE Objectives
 - Compliance with the American Recovery Act Objectives
 - Capture at least 75% of the CO₂ from a treated industrial gas stream that would otherwise be emitted
 - Project size shall be a large-scale industrial CCS project producing 1 million metric tons/year
 - CO₂ must be sequestered in underground geologic formation
 - Monitoring, verification, and accounting (MVA) of sequestered CO₂
 - On-stream prior to September 2015
- Additional Air Products' Objectives
 - No negative impact to Hydrogen business
 - Demonstrate real-world CO₂ capture economics



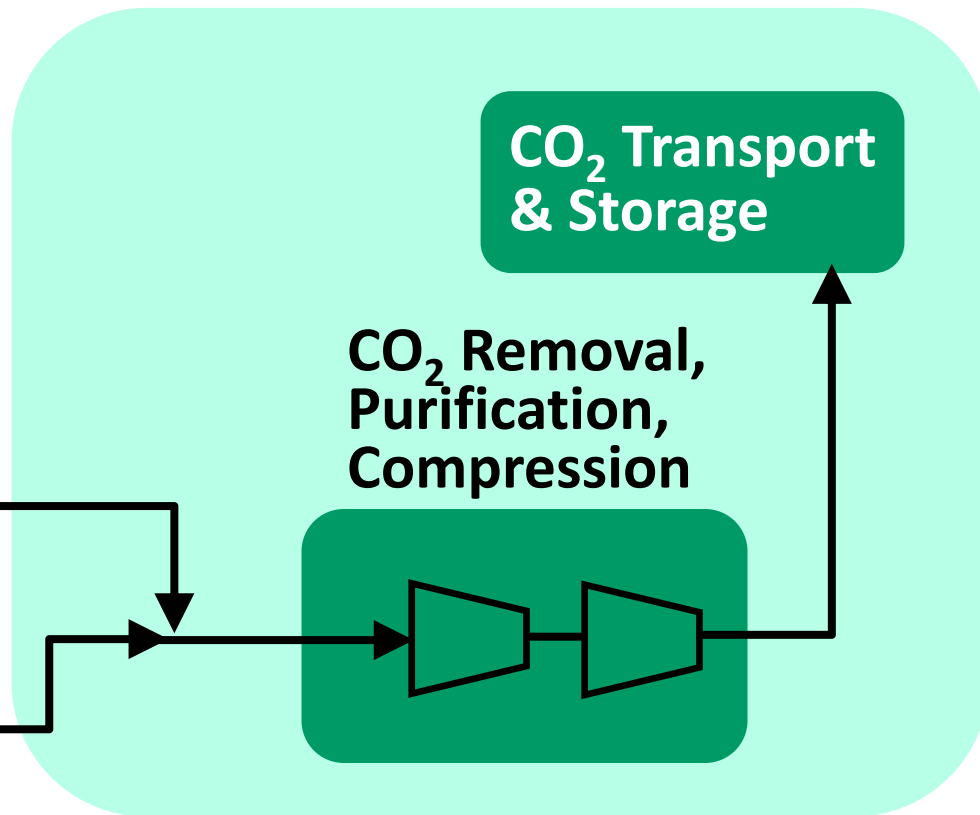
CO₂ Capture Project

Port Arthur I & II: Integrated Cogeneration and Hydrogen Plants

H₂
Export Steam

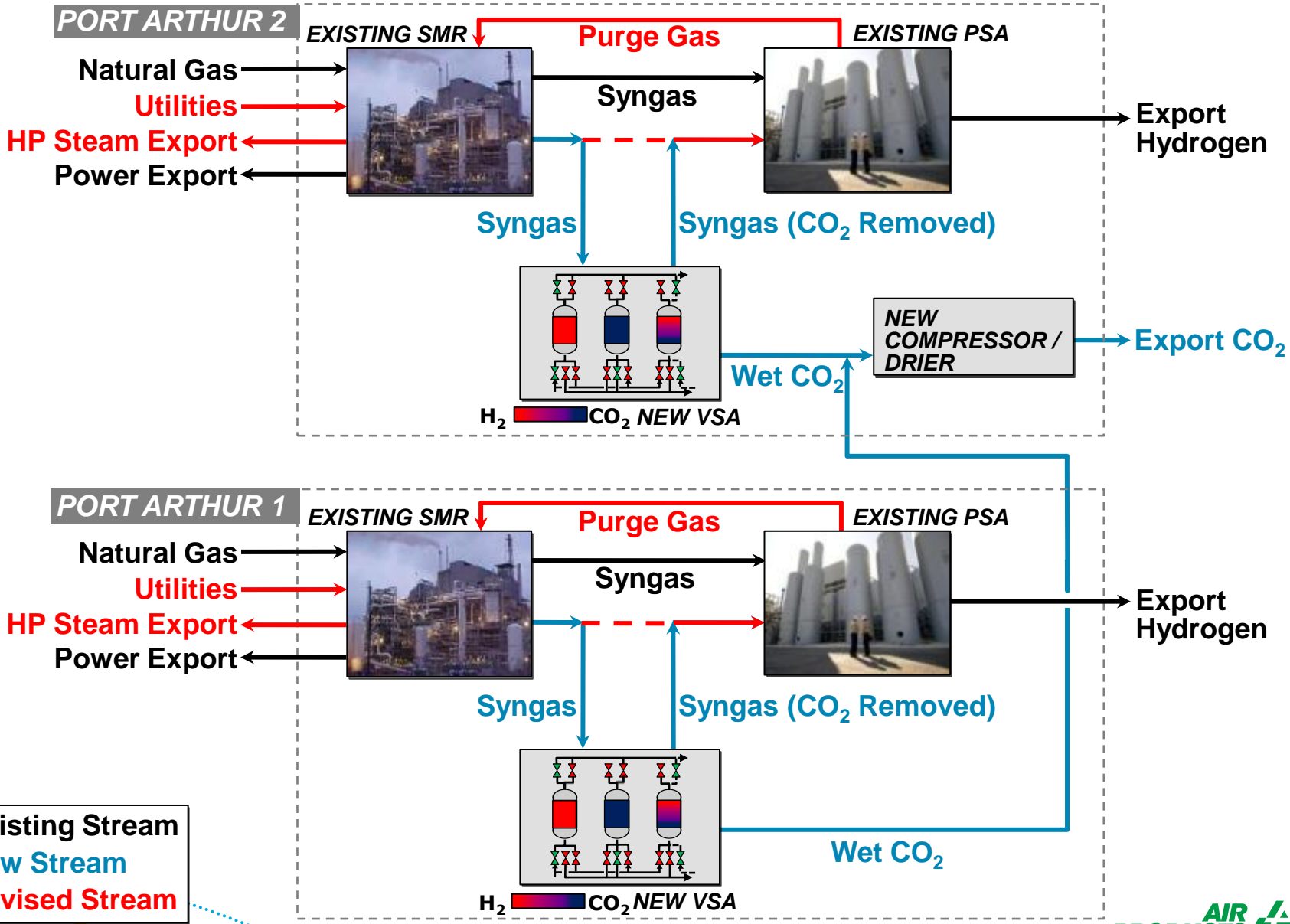


H₂
Power Generation
Export Steam

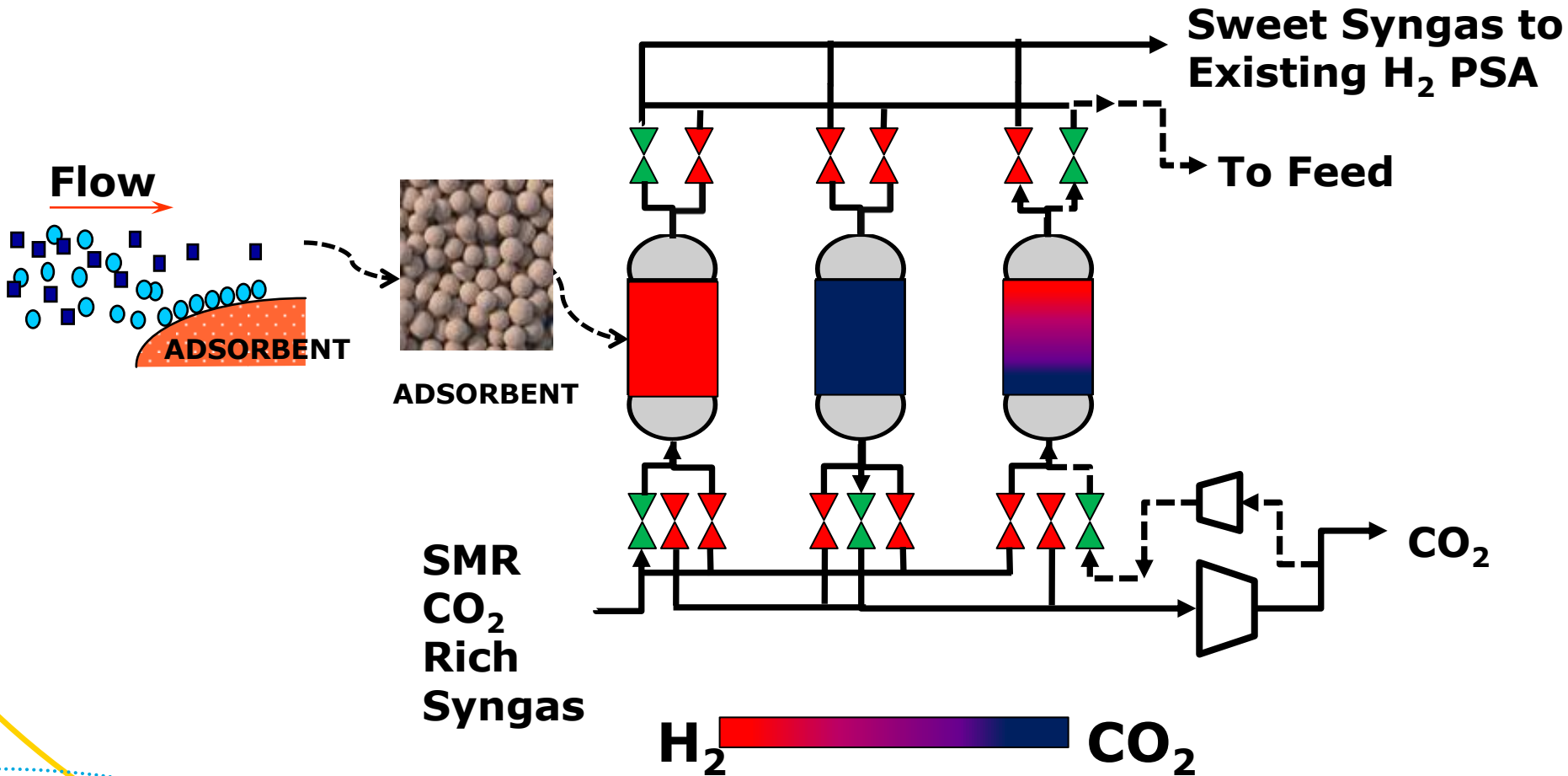


DOE Phase 2 Award,
Industrial Carbon Capture

Simplified CO₂ Capture Block Flow Diagram



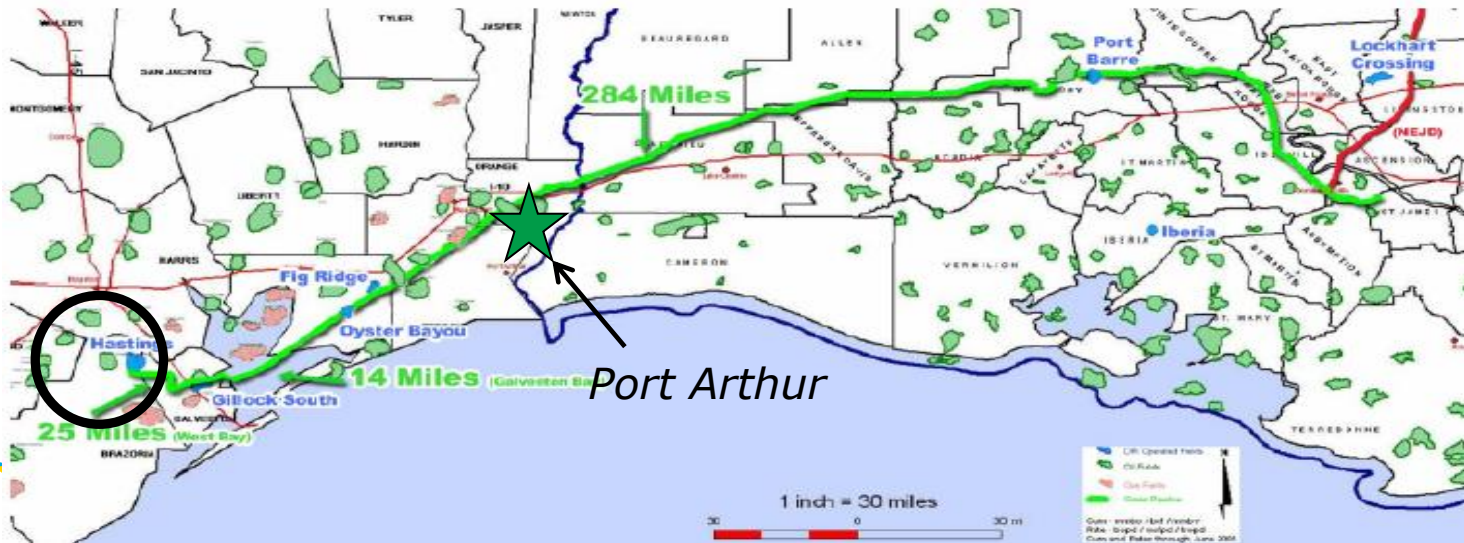
Vacuum Swing Adsorption Process for CO₂ Separation



Key Project Components

Capturing CO₂ for Denbury's "Green Pipeline"

- Vacuum swing adsorption (VSA) vessels
- Tri-ethylene glycol (TEG) drier system
- CO₂ export compressor
 - 8 stages
 - Export pressure over 2000 psig (~140 bar)
- 13 mile (21 km) CO₂ Pipeline connecting to Denbury's "Green" 300+ Mile (~500 km) CO₂ Pipeline



9 Map shows Denbury's Green CO₂ Pipeline. Data source is Denbury, December 2011, CO₂ Flooding Conference

Progress and Current Status of Project

- Site Demo – Complete
- FONSI issued – Complete
- Pilings – Complete
- Foundations – Complete
- Mechanical Construction – Jan. 2012
- Projected CO₂ Capture On-stream:
 - PA-II SMR: Late 2012
 - PA-I SMR: Early 2013



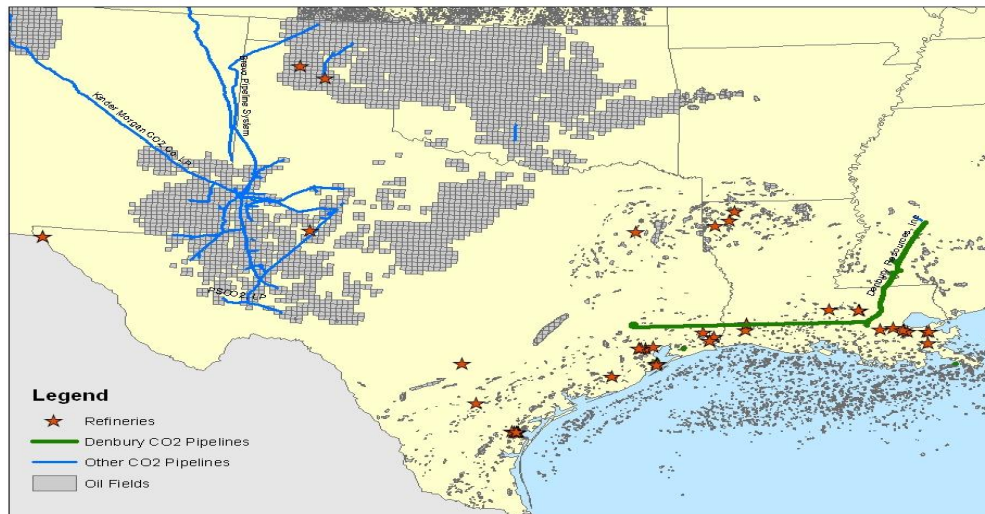
Project Challenges

- Technical Challenges
 - Integration with existing hydrogen business
 - Technology Scale-up
- Economic Challenges
 - 45Q Tax Credits
 - Schedule
 - Capital
 - Retrofit project within active operating facility
 - Operating and Maintenance Costs



Plan for Future Commercialization

- Technical and economic results from this project are key to determining the most effective commercialization path
- DOE award funding has enabled demonstration
 - Existing CO₂ market does not support current CO₂ capture economics without external funding
- www.airproducts.com/co2_capture
- www.h2alliance.com



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