Scale-Up and Testing of Advanced Polaris Membrane CO_2 Capture Technology (DE-FE0031591)

Tim Merkel, Jay Kniep, Thomas Hofmann
Membrane Technology and Research, Inc.

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Project Overview

Award name: Scale-Up and Testing of Advanced Polaris Membrane CO_2 Capture Technology (DE-FE0031591)

Project period: 8/1/18 to 7/31/21

Funding: $7.4 million DOE; $2.4 million cost share ($9.8 million total)

DOE program manager: Bruce Lani

Participants: MTR, Technology Centre Mongstad (TCM), Siemens/Dresser Rand, Trimeric, WorleyParsons

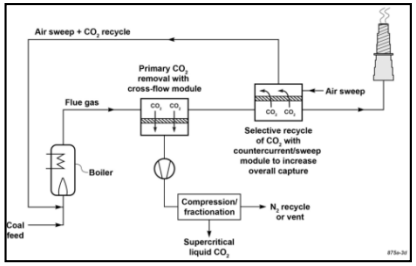
Project scope: Design, build, and operate a system at TCM with Advanced Gen 2 Polaris membranes and modules; optimize integration of compression and CO_2 purification equipment with membranes.

Project plan: The project is organized in three phases:

- **Phase 1/Year 1** – Design system, fabricate membrane modules
- **Phase 2/Year 2** – Build and install system; commission at TCM
- **Phase 3/Year 3** – Operate system, analyze results, decommissioning

MTR / DOE Development Timeline

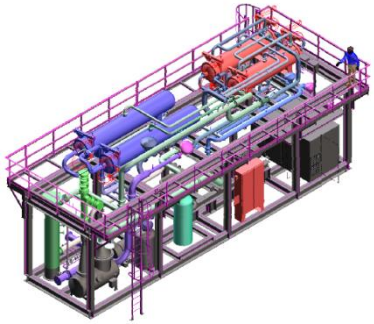
Feasibility study
- Sweep concept proposed
- Polaris membrane conceived



APS Red Hawk NGCC
- First Polaris flue gas test
- 250 lb/d CO_2 used for algae farm

APS Cholla Demo
- First Polaris coal flue gas test
- 1 TPD CO_2 captured (50 kW_e)

NCCC 1 MW_e Demo
- 11,000 hours of 1 TPD system operation
- 1 MW_e (20 TPD) system operation



Low Pressure Mega Module
- Design and build a 500 m^2 optimized module

Hybrid Capture
- Membrane-solvent hybrids with UT, Austin

B&W Integrated Test

TCM Advanced Polaris

TRL3 TRL4 TRL5 TRL6 TRL7 TRL8

2006 2008 2010 2012 2014 2016 2018 2020

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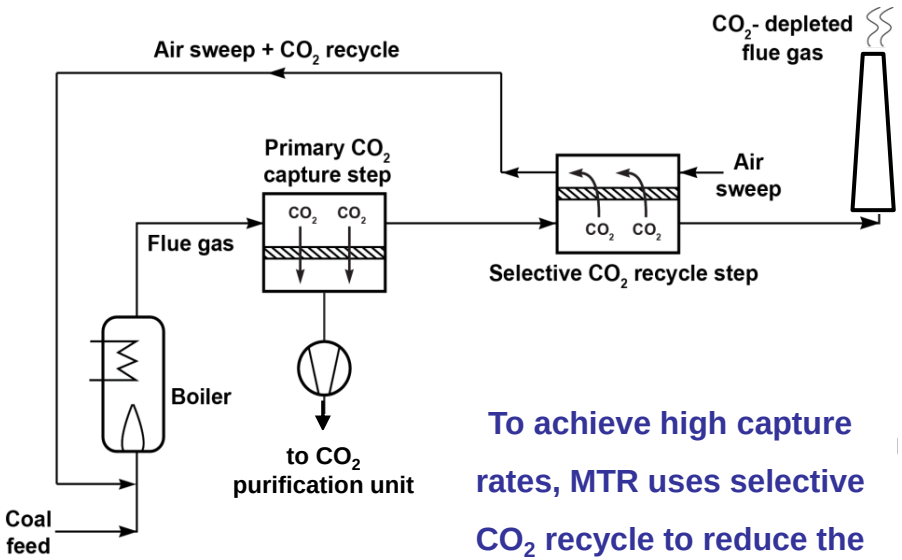
Background: Process and Material Innovations

Selective Exhaust Gas Recycle Design

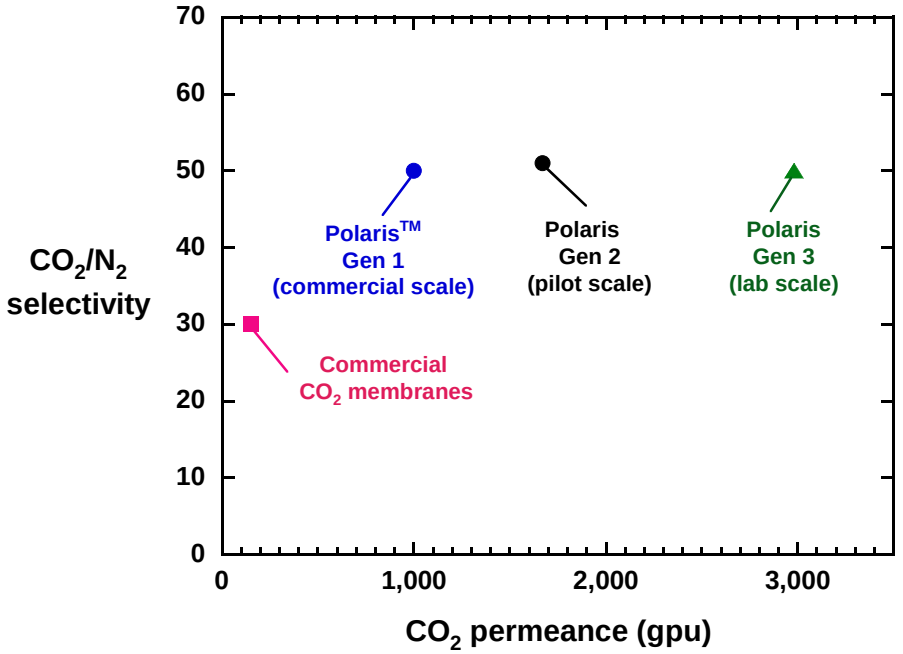


U.S. Patents 7,964,020 and 8,0

361-Pres062215

To achieve high capture rates, MTR uses selective CO_2 recycle to reduce the cost of capture

Polaris™ Membranes



- Selective recycle to boiler was recently validated in testing at B&W
- Gen 1 Polaris evaluated in extensive testing at NCCC (>11,000 hours)
- Systems analysis shows improved membrane permeance and reduced module pressure drop important to lower costs

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Background:
Small Pilot Testing at NCCC

- MTR small pilot completed 6 months of operation at NCCC followed by an integrated boiler test at B&W

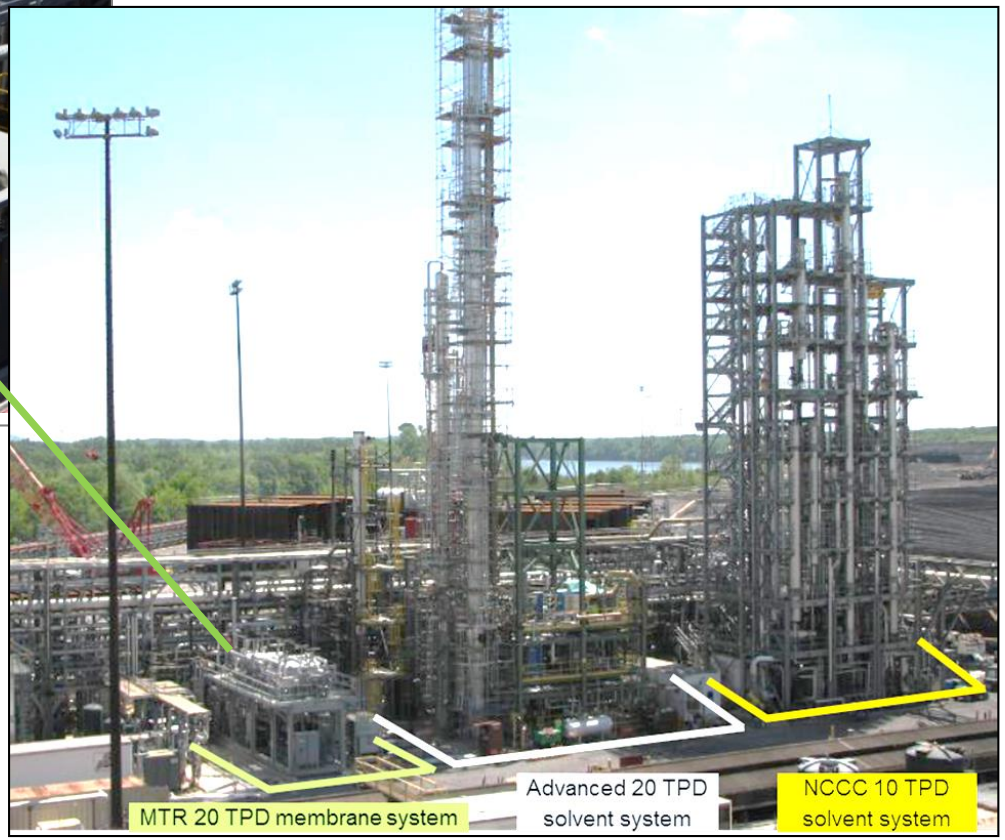
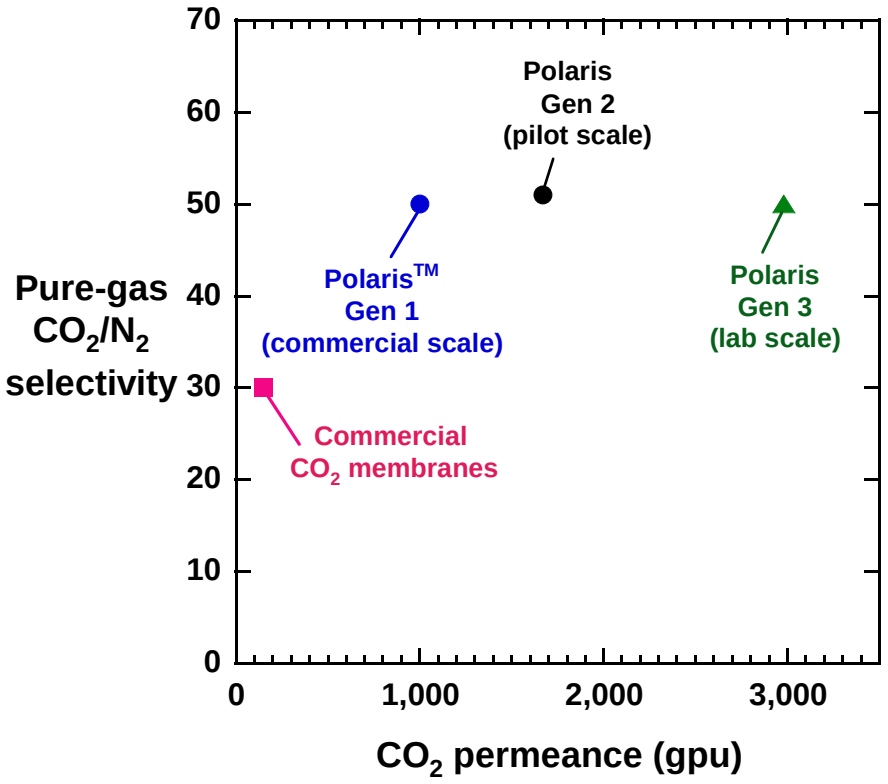


Photo Courtesy of NCCC

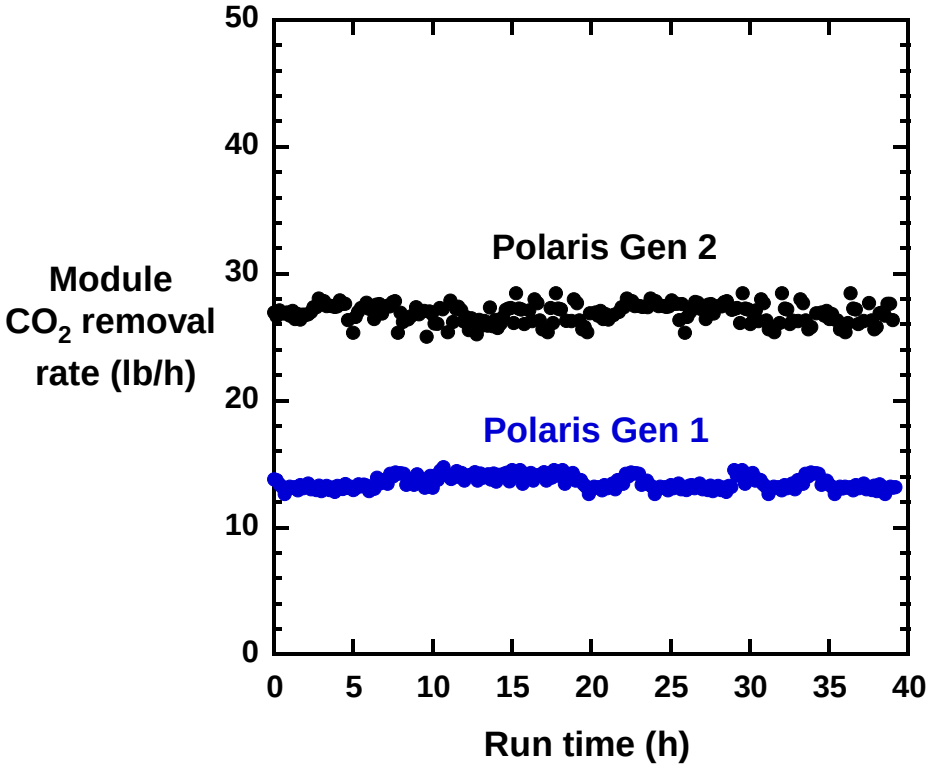
- System used Gen 1 Polaris and bundled spiral modules
- Parametric testing included prototype Gen 2 Polaris membrane and new low-pressure-drop modules

Testing at NCCC Confirmed Better Performance with Gen 2 Polaris

Stamp tests at MTR



Module tests at NCCC

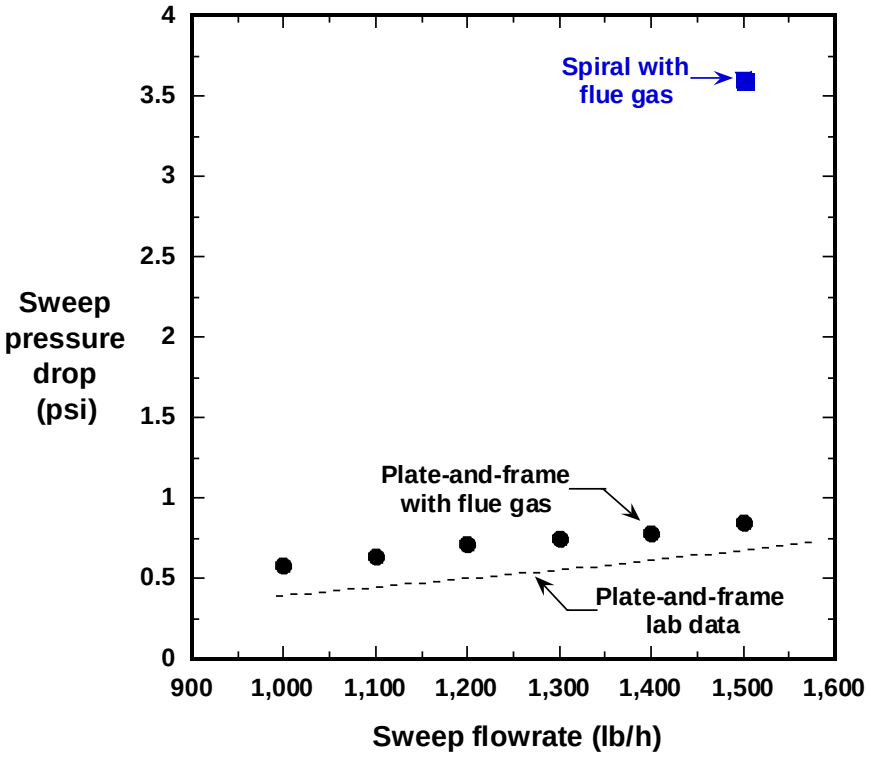


- Membrane system-size scales almost linearly with CO_2 permeance
- Higher permeance reduces capital cost and footprint

New Modules Have Much Lower Pressure-Drop

Module size

Module pressure-drop



- Reduced pressure-drop with new module saves ~15 MW_e of blower energy at full-scale
- New module performance validated at both NCCC and B&W field tests

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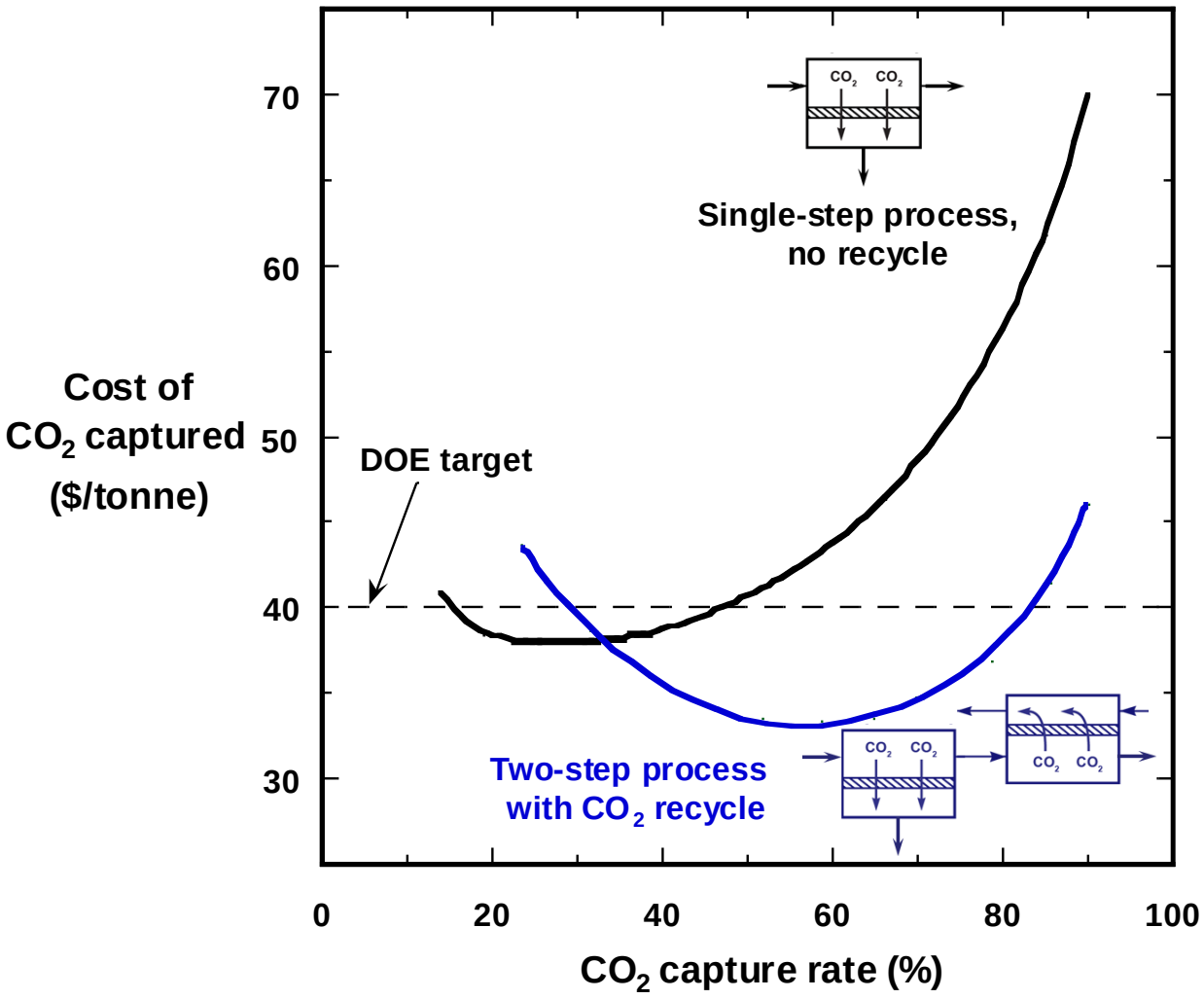
Partial Capture: Membrane Sweet Spot



- Membranes show a minimum in capture cost
- To reduce coal plant emissions to that of a natural gas plant requires 40-50% capture

Objectives of This Project

- Scale-up and operate pilot system using Gen 2 Polaris packaged in low-pressure-drop modules at TCM
- Demonstrate “containerized” skid as final form factor for future large-scale systems
- Focus TCM testing and TEA on membrane “sweet spot” → 50% – 80% capture
- With partners, optimize integration of pump/compression equipment (Siemens) and CO_2 purification unit (Trimeric)

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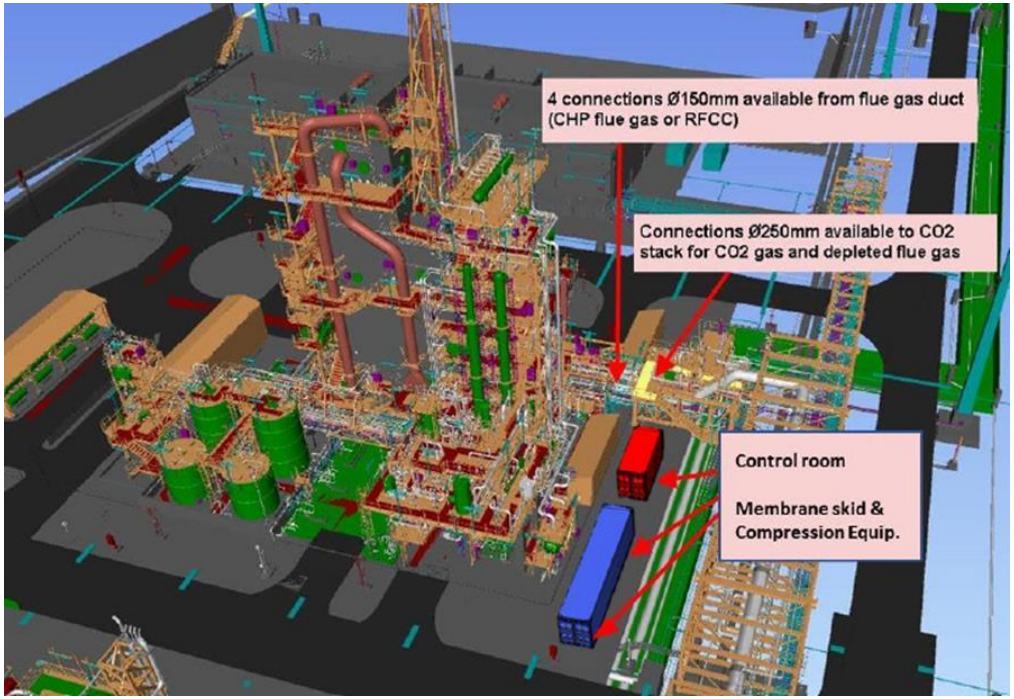
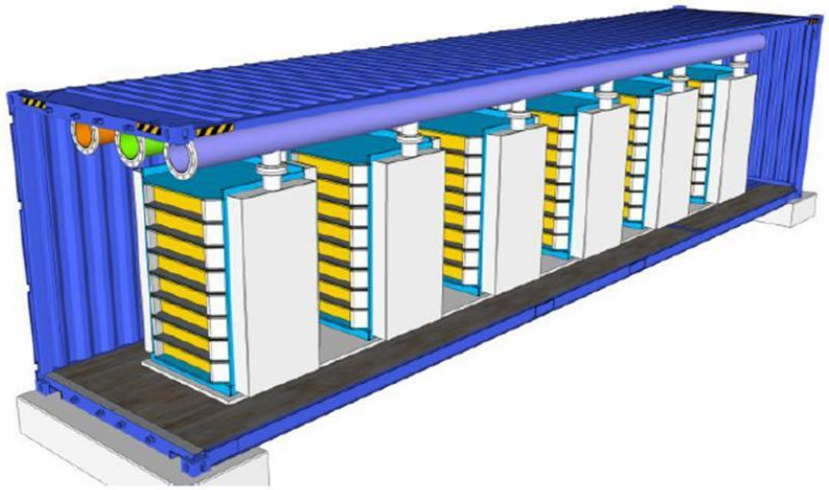
Preliminary Drawings of Advanced Polaris System

TCM layout showing possible MTR skid location



Polaris Gen 2 modules bundled in low-cost container

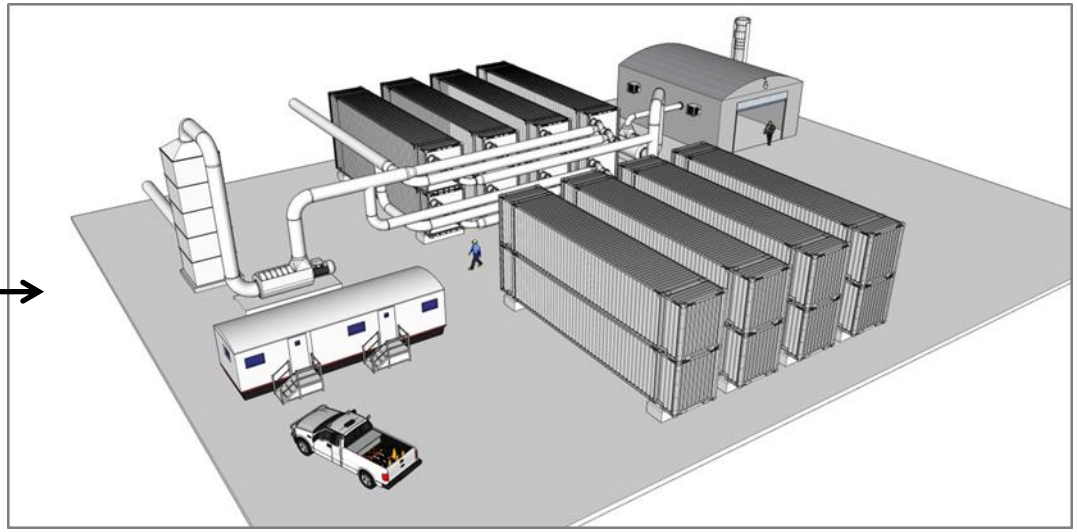


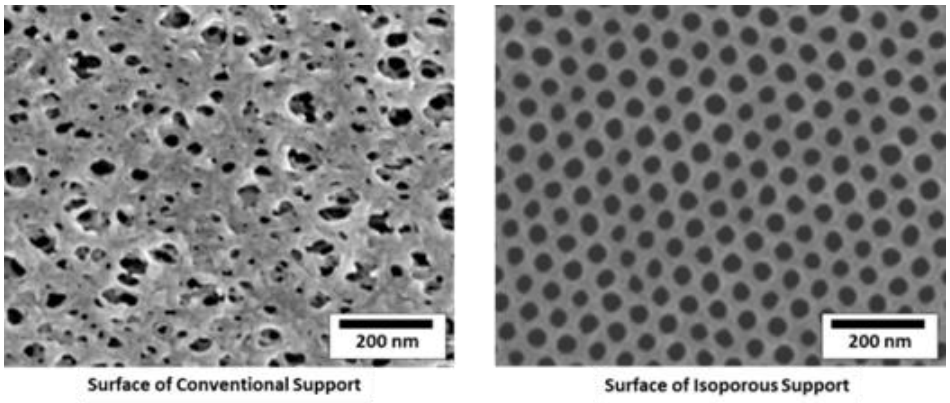
- Goal is 6 months of parametric and steady state testing in project year 3 (2020/21)

Complementary New DOE Projects

200 TPD Large Pilot

(DE-FE0031587; Richard Baker/Brice Freeman) – will use improved membrane and containerized modules demonstrated at TCM





Isoporous Membrane
(DE-FE0031596; Hans Wijmans) – offers potential for step-change improvement in Polaris to reduce capture cost to $30/tonne

Summary

- This project will scale-up and validate in field testing at TCM recent innovations in membrane (Gen 2 Polaris) and modules (low-pressure-drop)
- The next-generation membranes/modules will be packaged in a container that represents the final form factor for this capture technology
- These advances will reduce costs toward $40/tonne and can be implemented in a future large pilot

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Acknowledgements

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  - José Figueroa
  - Bruce Lani

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