



MEMBRANE
TECHNOLOGY & RESEARCH

Scale-Up and Testing of Advanced Polaris Membrane CO₂ Capture Technology (DE-FE0031591)

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Carbon Capture, Utilization, and Storage Integrated Review Meeting
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Outline

- Project overview and team
- Technology background
- Project objectives
- Progress to date

Project Overview

Award name: Scale-Up and Testing of Advanced Polaris Membrane CO₂ 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: Andy Aurelio

Participants: MTR, TCM, Siemens/Dresser Rand, Trimeric, WorleyParsons

Project scope: Design, build, and operate a system at TCM with Gen 2 Polaris modules

Project plan: The project is organized in three phases:

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

Role of Participants

- MTR – project lead and liaison with DOE; responsible for membrane system design, construction, installation and operation; will lead data analysis and all reporting to DOE
- TCM – host site for the field test; with MTR, will coordinate system installation, operation, and data analysis
- Siemens/Dresser Rand – will lead engineering study on optimization of rotating equipment (blowers, vacuum pump, CO₂ compression) for MTR process
- Trimeric – will lead the CO₂ purification unit (CPU) optimization study and responsible for overall process TEA
- WorleyParsons – responsible for process environmental impact study

MTR Development Timeline

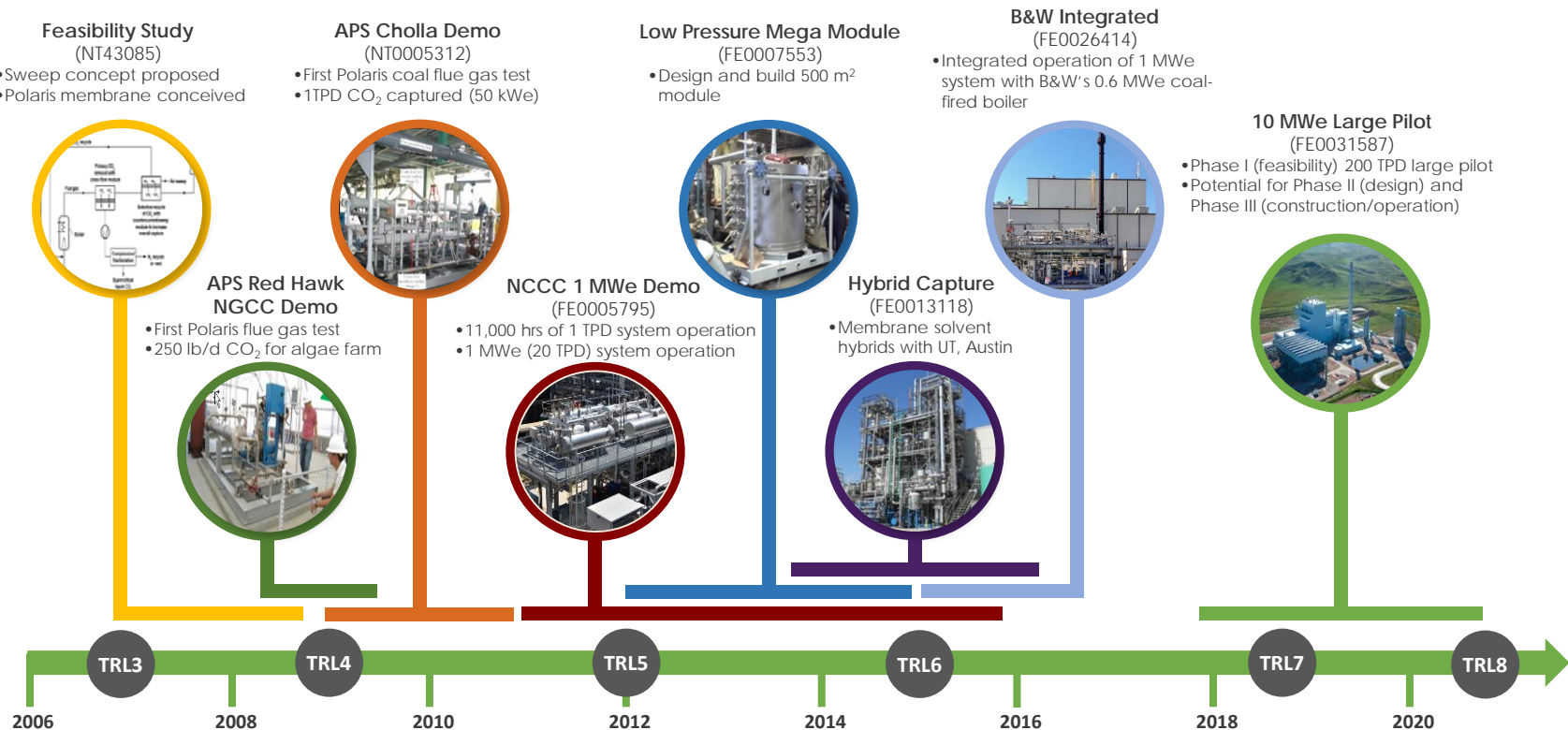


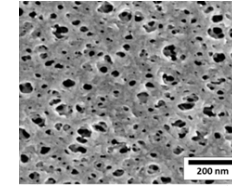
Figure courtesy of DOE

Current MTR Projects

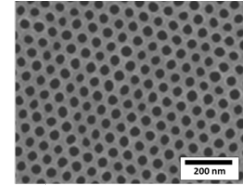


Self-Assembly Isoporous Supports, CA (DE-FE31596)

- Transformational new membrane (TRL 3 – 4)
- Reduces membrane area and energy use



Surface of Conventional Support



Surface of Isoporous Support



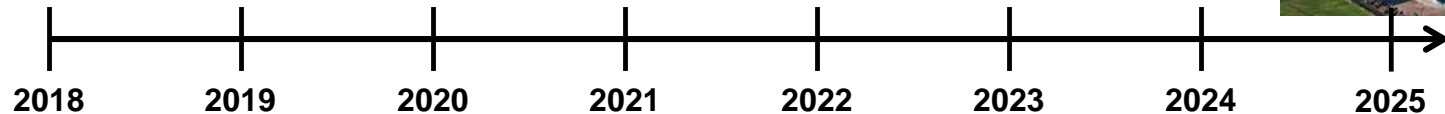
Pilot Testing at TCM, Norway (DE-FE0031591)

- Gen 2 Polaris™ membrane
- Low pressure-drop modules
- Containerized skid, 1 MW pilot scale



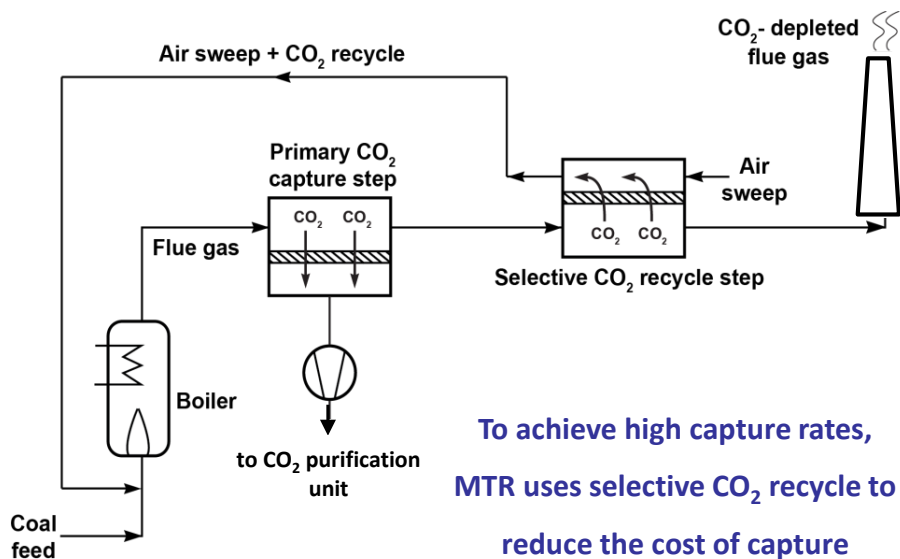
Large-Pilot Testing at WY ITC, WY (DE-FE31587)

- Phase I – Design 200 TPD pilot; secure host site
- Phase II – FEED and permitting
- Phase III – Fabricate, install and operate (TRL 7 – 8)



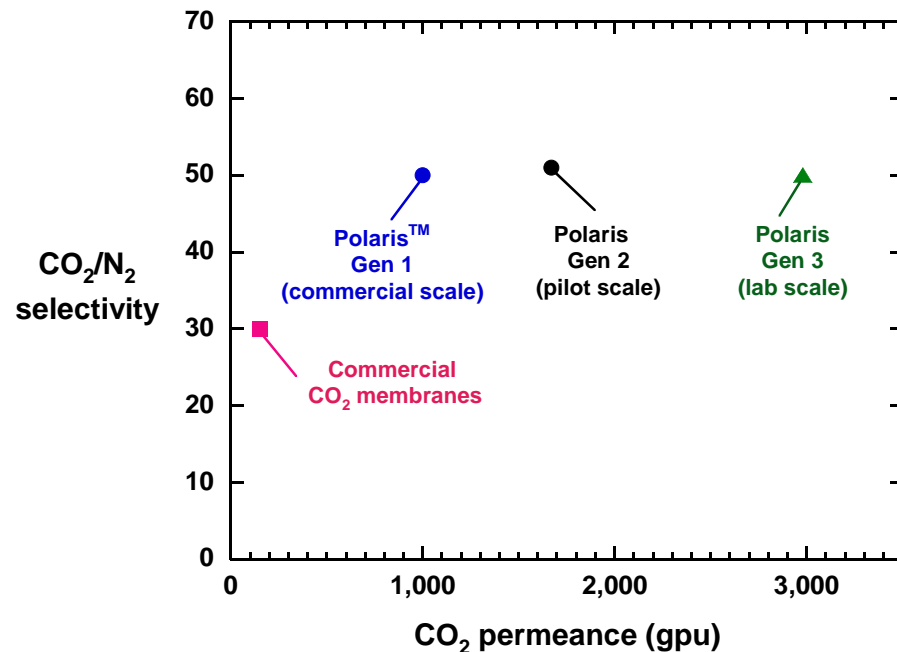
Background: Process & Material Developments

Selective Exhaust Gas Recycle Design



U.S. Patents 7,964,020 and 8,025,7

Polaris™ Membranes



- Selective recycle to boiler was validated in testing at B&W
- Gen 1 Polaris evaluated in extensive testing at NCCC (>11,000 hours)

Background: Small Pilot at NCCC



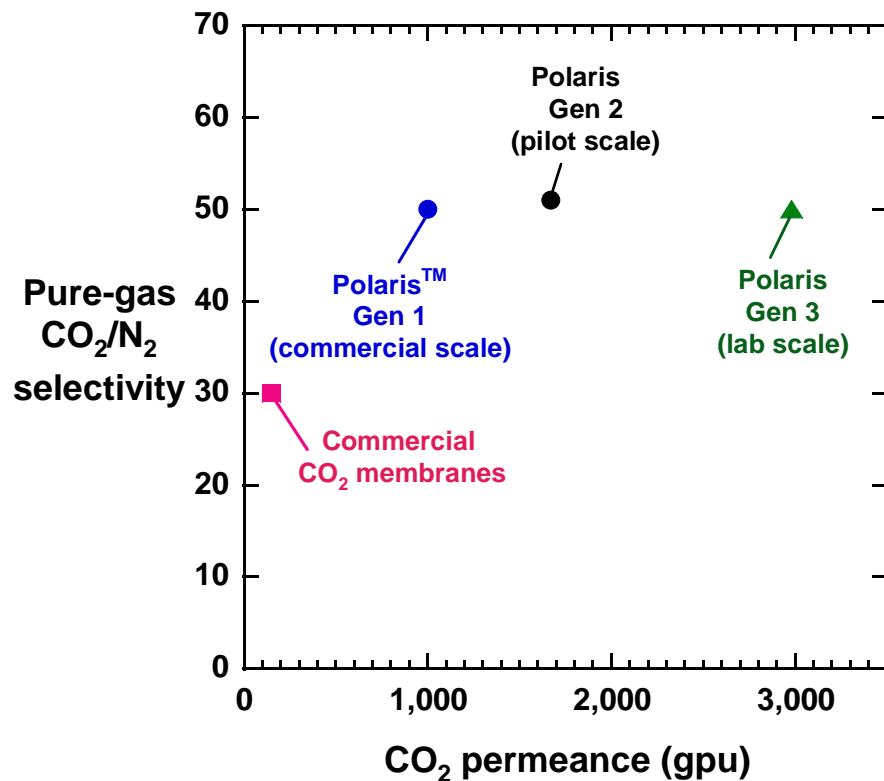
- Conducted comparison of Gen1 and 2 membrane
- CO₂ removal performance was good, but pressure drop was relatively high

- Membranes are simple and compact
- MTR pilot system was tested at NCCC and B&W

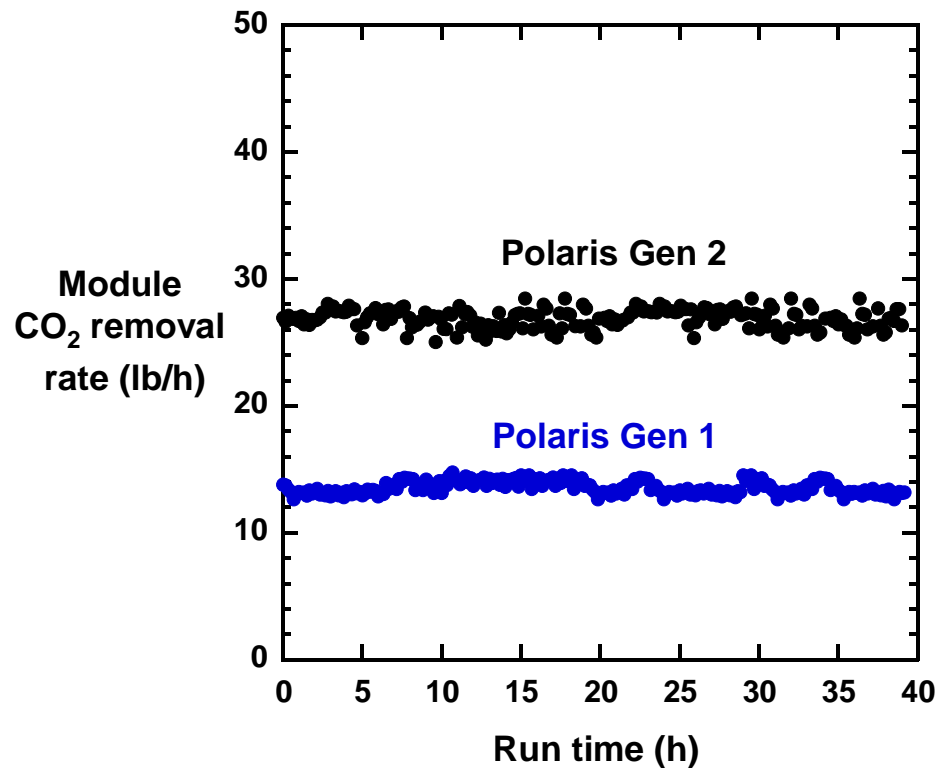


- NCCC Testing Confirmed Better Gen2 Performance -

Stamp tests at MTR



Module tests at NCCC



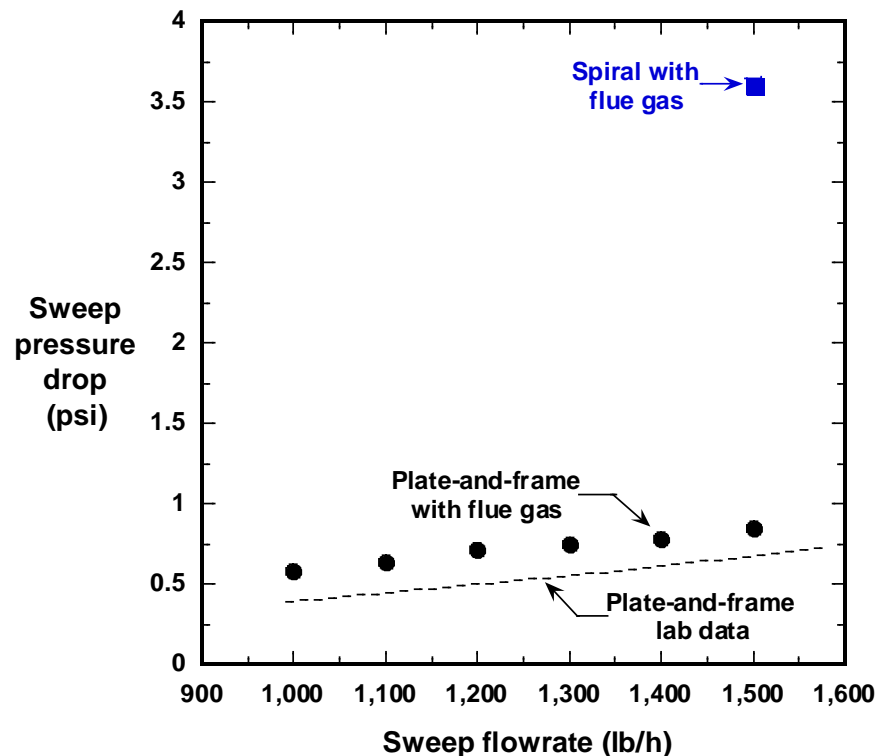
- Higher permeance reduces capital cost and footprint

New Modules Have Lower Pressure Drop

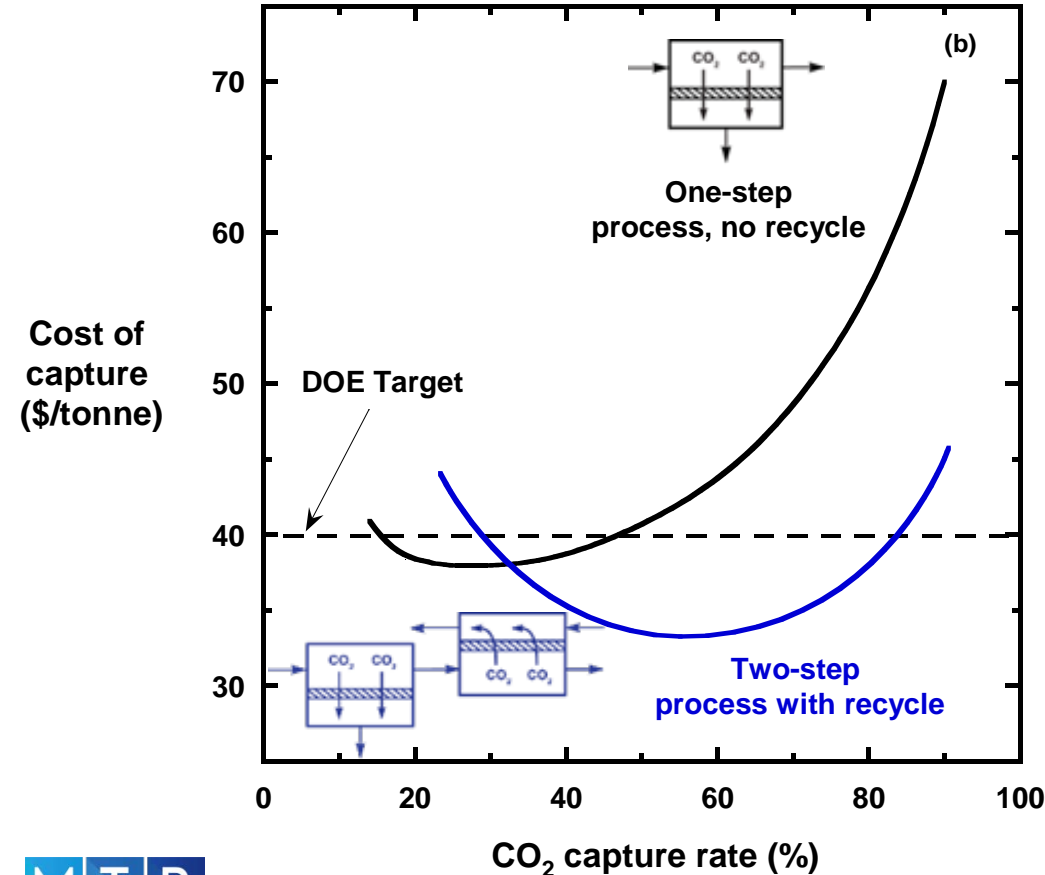
Module size



Module pressure-drop



Membrane Capture Cost vs Rate



- Membranes are best for bulk separations. There is a sweet spot for the technology between 50 – 80% capture
- Selective recycle design reduces capture cost by as much as \$25/tonne at 90% capture (including boiler de-rate measured at B&W)

Project Objectives

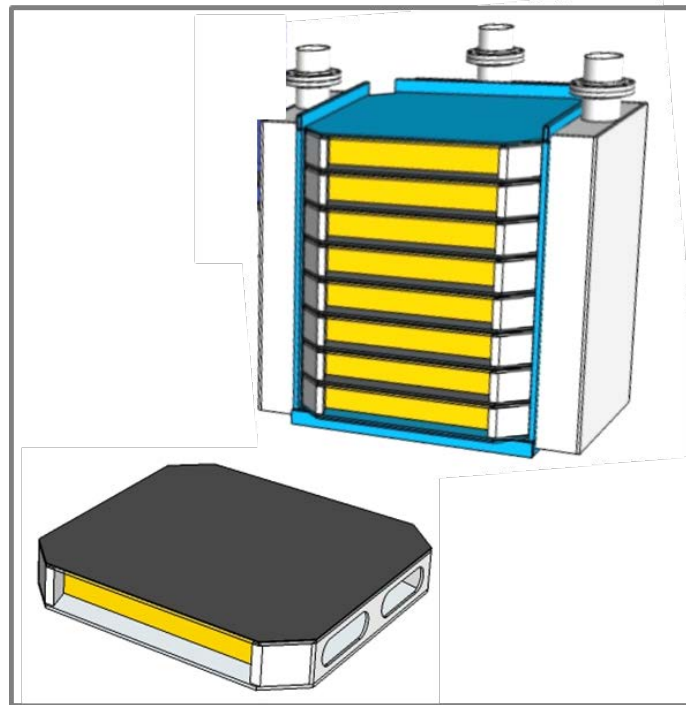
- Scale-up Gen 2 Polaris packaged in low-pressure-drop, low-cost module stacks and test at TCM
- Demonstrate “containerized” skid as final form factor for future large-scale systems
- Test pilot system (~1 MW) over range of CO₂ capture rates and feed CO₂ content for TEA input
- With partners, optimize integration of pump/compression equipment (Siemens) and CO₂ purification unit (Trimeric)

TCM Test Will Use Improved Modules

Prototype at NCCC/B&W 2015-17



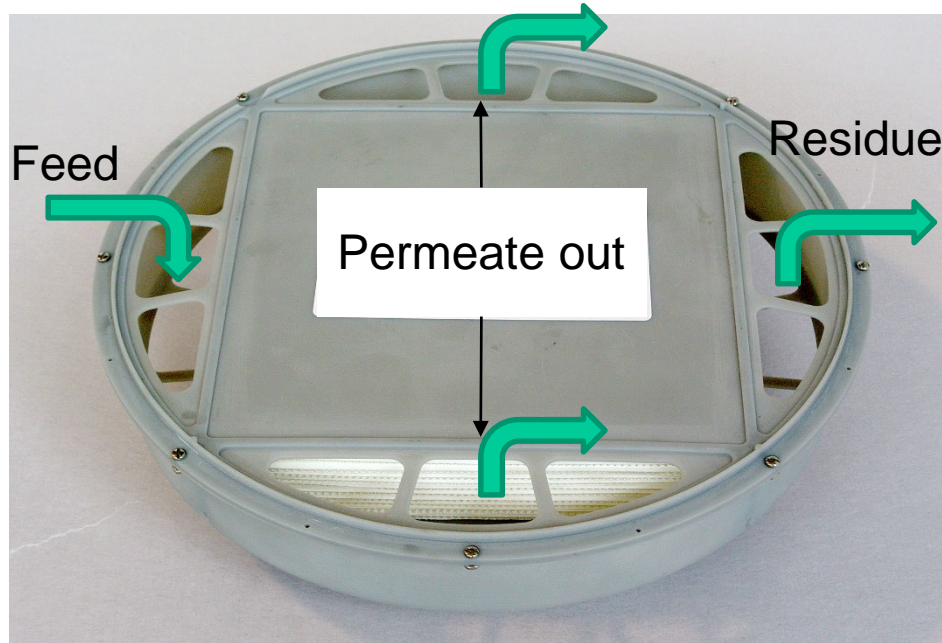
Polaris Planar Stack at TCM 2020



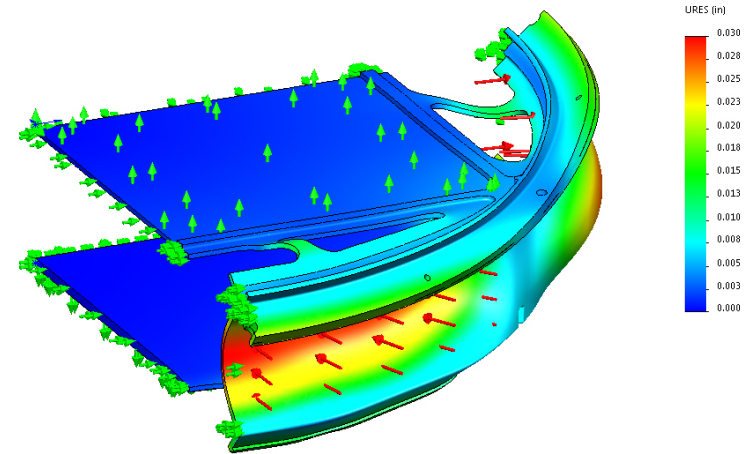
- New plastic module housing is low-cost, lightweight

Sample Modules Built and Analyzed

1/6th Scale Housing with Membrane



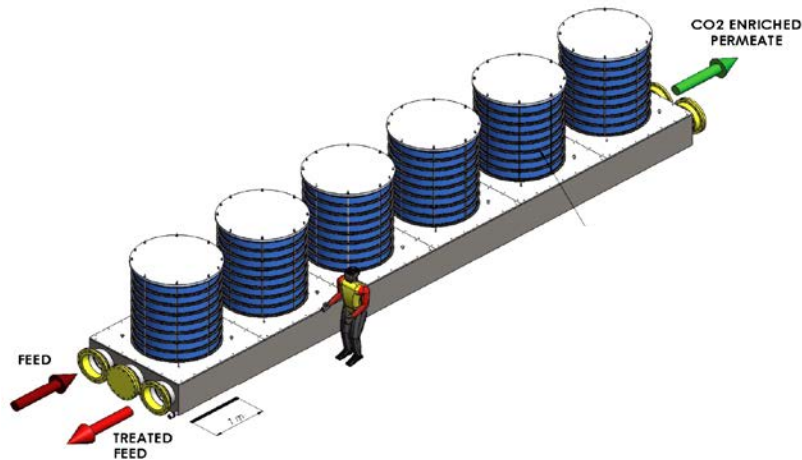
Housing Deformation Under Load



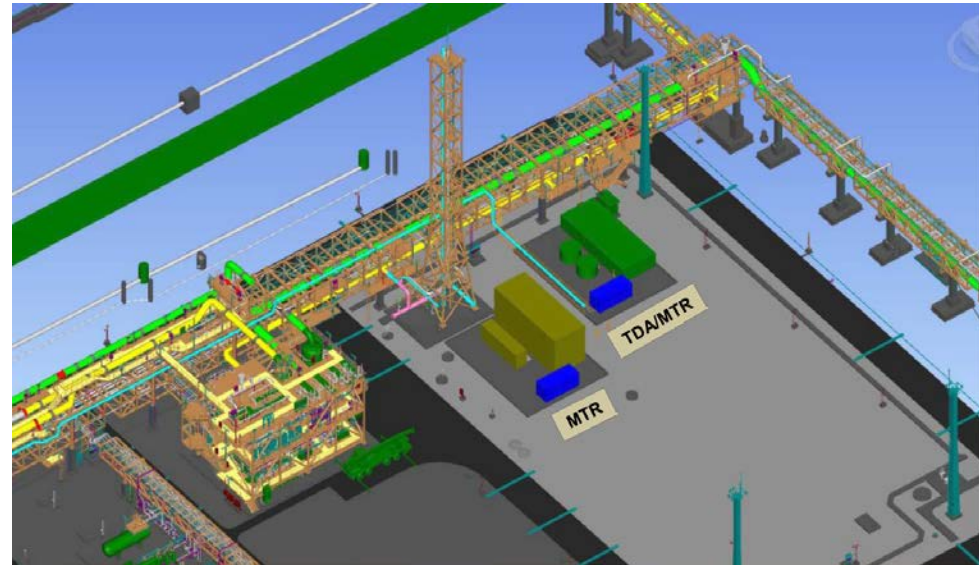
- Full size membrane stacks now under construction

Containerized Skid at TCM

Cutaway of Container Skid with Membrane Stacks

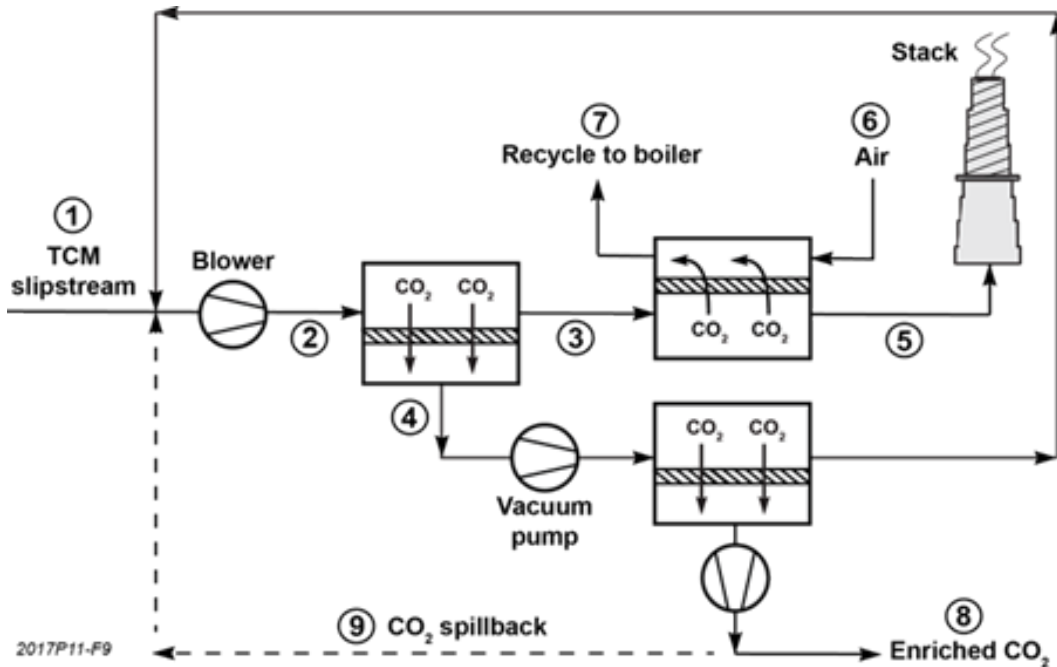


Layout for Skid at TCM



- Membrane skid will be installed at TCM “3rd site” being developed for new technologies

Membrane Skid Design



- 2 stage system with ability to test air sweep step (stream 5) and varying feed CO₂ content using recycle (stream 9)
- Mass balances and equipment sizing completed, quotes received, fabricator selected
- Internal Hazop completed; overall Hazop with TCM scheduled for Sept
- Design to be finalized and ready to commence construction by start of BP 2 (Nov 1)

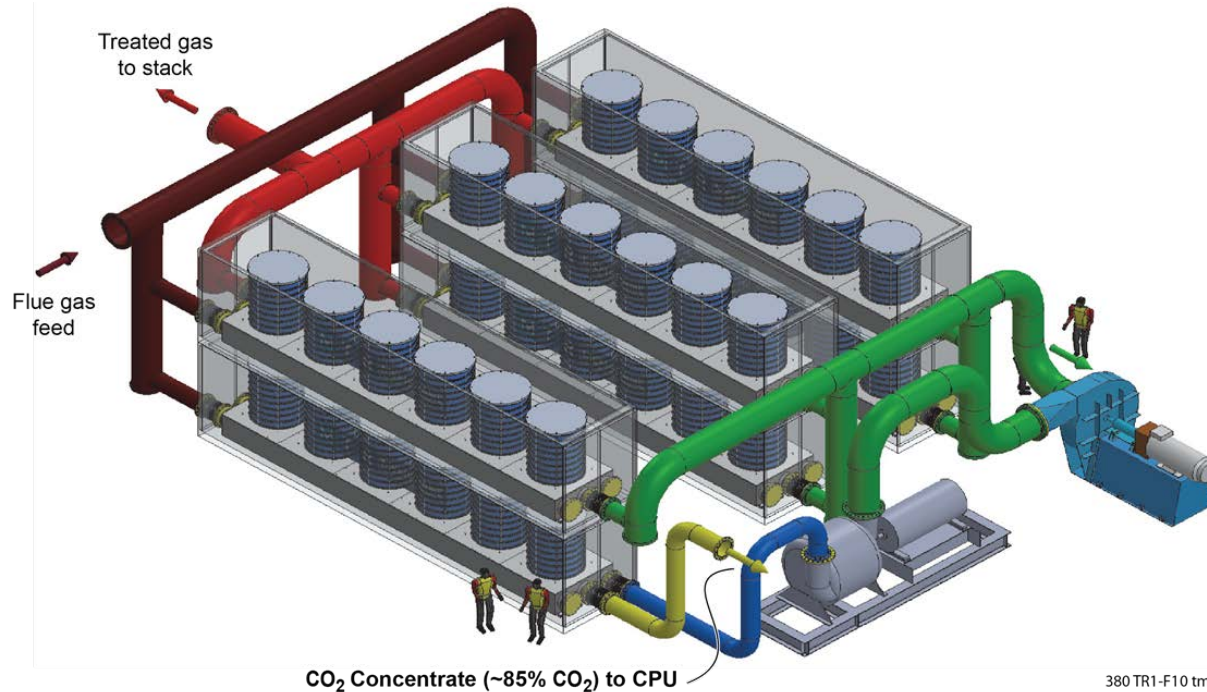
Preliminary Test Plan

- Vary capture rate without sweep step or spillback
- Vary capture rate with sweep step using spillback to mimic enriched CO₂ feed content
- During these parametric steady state tests, monitor separation efficiency, system pressure drops, and gas compositions to CPU
- Run dynamic tests (startup/shutdown, load change) to document membrane response time
- At end of program, vary particulate feed to system and monitor fouling/pressure drop
- Final test plan to include input from CCSI2

Current Status

- Gen 2 Polaris membrane rolls have been made on commercial roll-to-roll equipment
- Module stack assembly has started
- Stack housing design completed; components to be ordered in next month
- Containerized skid initial design completed; final Hazop review with TCM in Sept
- BP2 starts Nov 1; all BP1 milestones/success criteria met

Path Forward: 200 TPD System



- Containerized membrane stack, to be tested at TCM, is envisioned as the final form factor for this capture technology
- Future, larger systems will simply use multiples of this basic building block

Summary

- Main goal is to validate recent innovations in membranes (Gen 2 Polaris) and modules (low-pressure-drop) in field testing at TCM
- Membranes will be packaged in a container that represents the final form factor for this capture technology
- Project is nearing end of the design phase (BP1) and almost ready to begin construction (BP2)

Acknowledgements

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 - Vlad Vaysman



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Thank you for your attention!