

# Low-Pressure Membrane Contactors for Carbon Dioxide Capture DE-FE0007553

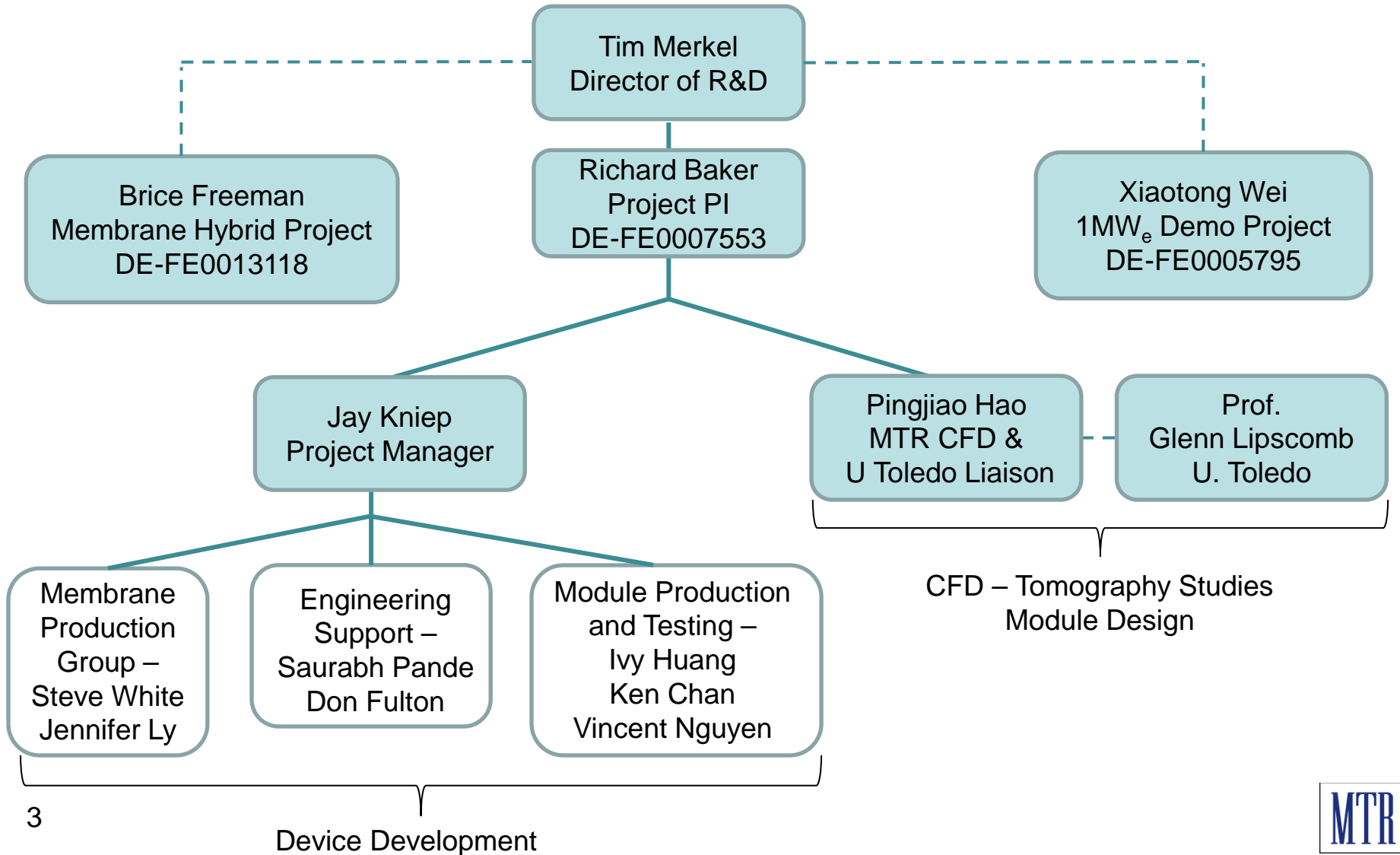
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–Glenn Lipscomb, Terry Lou (University of Toledo)
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**NETL CO<sub>2</sub> Capture Technology Meeting**  
Thursday July 31, 2014

# Project Overview

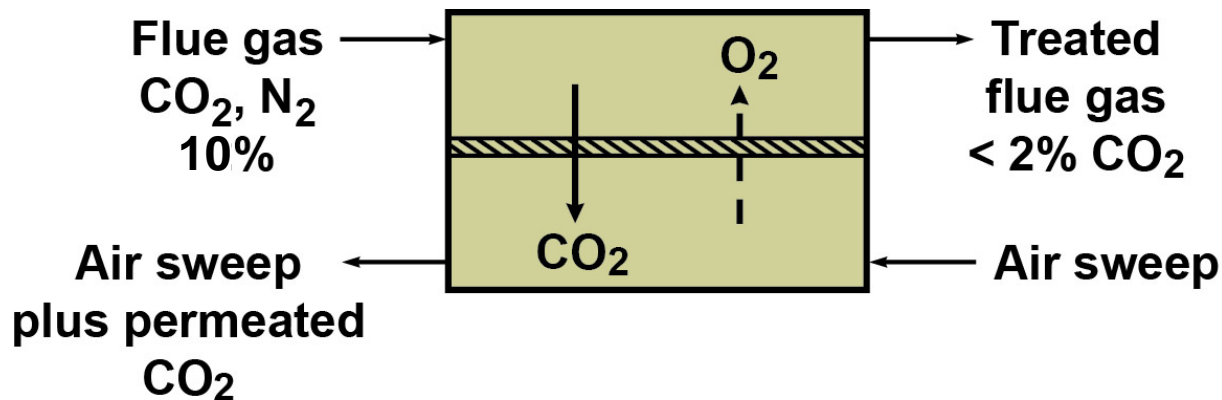
- **Award name:** Low-Pressure Membrane Contactors for CO<sub>2</sub> Capture
- **Project period:** 10/1/11 to 9/30/14
- **Funding:** \$ 3.0 million DOE; \$1.0 million MTR
- **DOE project manager:** Mike Mosser
- **Participants:** MTR, University of Toledo
- **Project scope:** Develop compact large membrane area (> 500 m<sup>2</sup>), low pressure drop plate-frame sweep module for CO<sub>2</sub> capture application.
- **Project plan:** The key project work organized by budget period is as follows:
  - **BP1:** Construct prototype laboratory modules (20m<sup>2</sup>), select components, develop fabrication technology.
  - **BP2:** Scale up production to 1m x 1m pilot scale modules (100m<sup>2</sup>), demonstrate with lab test system that modules meet CO<sub>2</sub> separation performance and pressure drop targets.
  - **BP3:** Scale up to full scale module (> 500 m<sup>2</sup>), show modules meet all performance targets. Be ready to test at NCCC.

# MTR CO<sub>2</sub> Capture Team



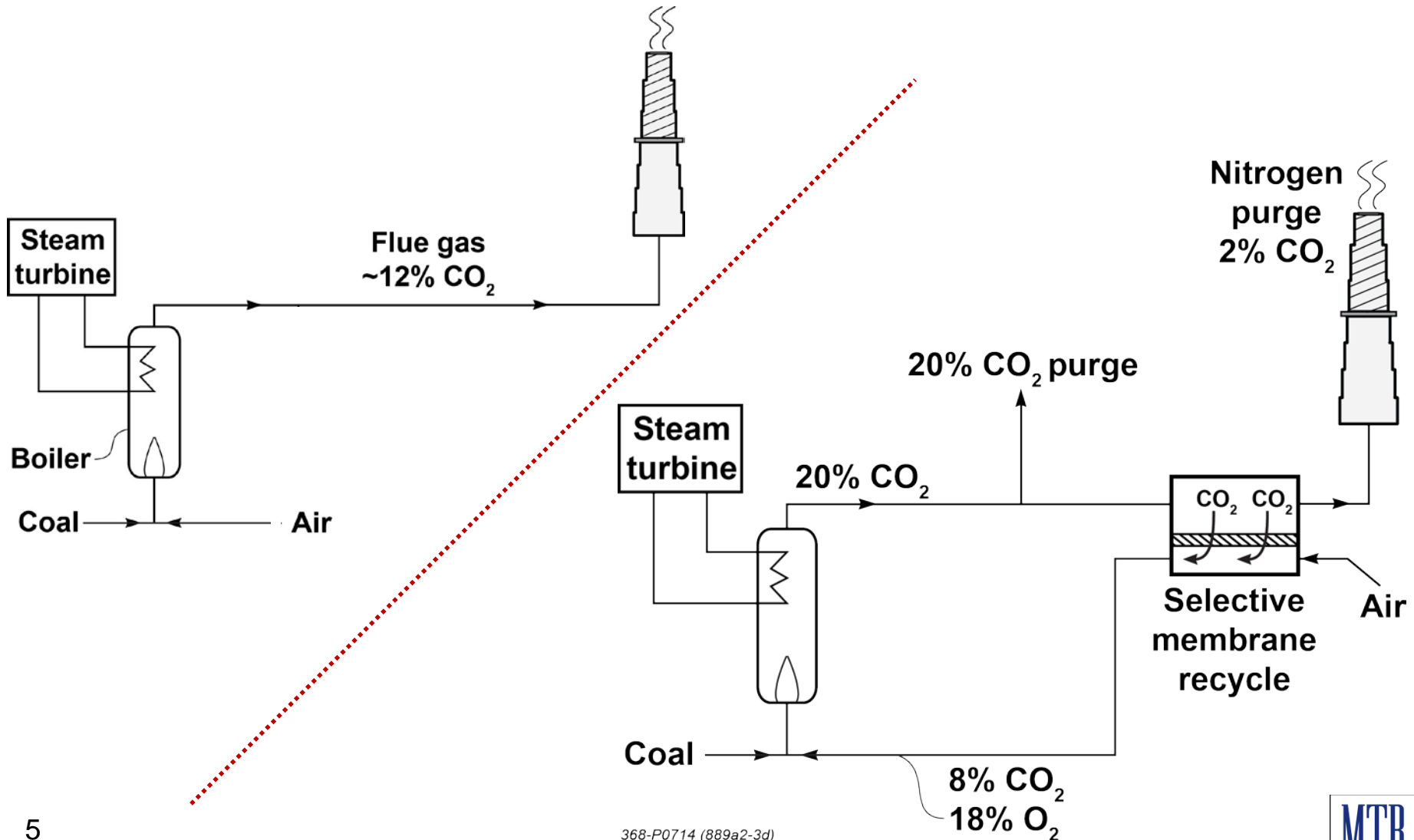
# The MTR Membrane Contactor

## *A Way of Generating an Affordable (Partial) Pressure Difference*

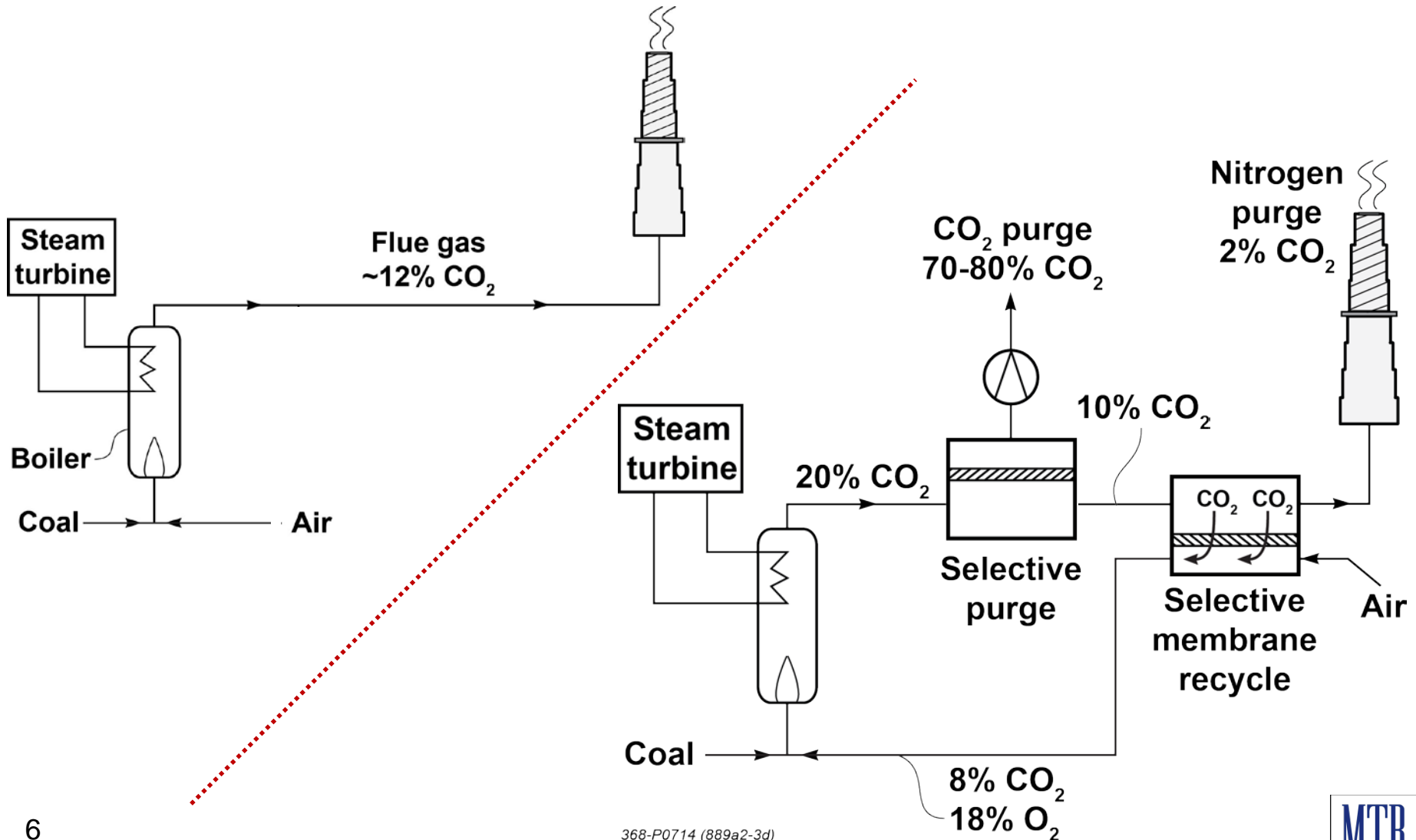


A separation is performed at a minimal energy cost.

# Coal Power Plant with a Membrane CO<sub>2</sub> Pre-Concentrator

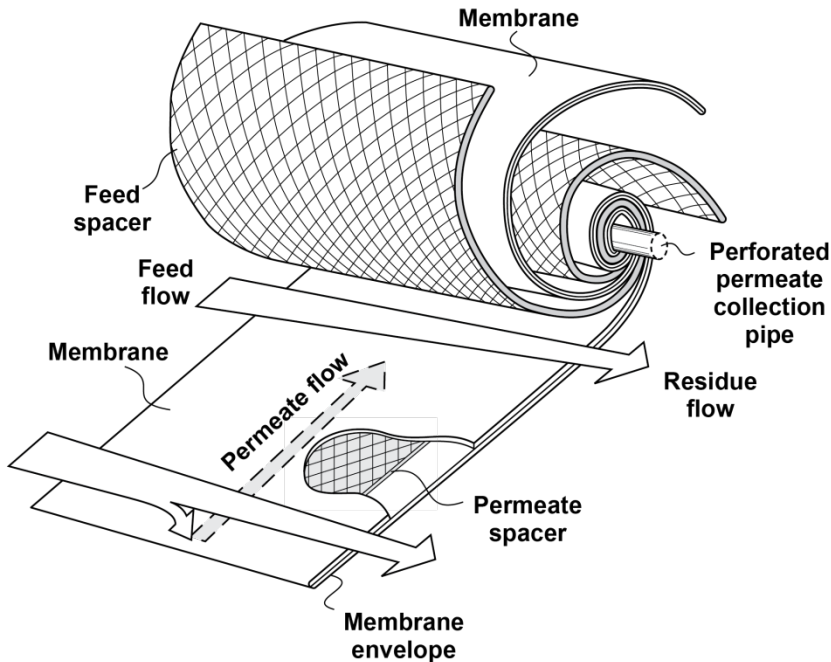


# Coal Power Plant with a Membrane CO<sub>2</sub> Pre-Concentrator

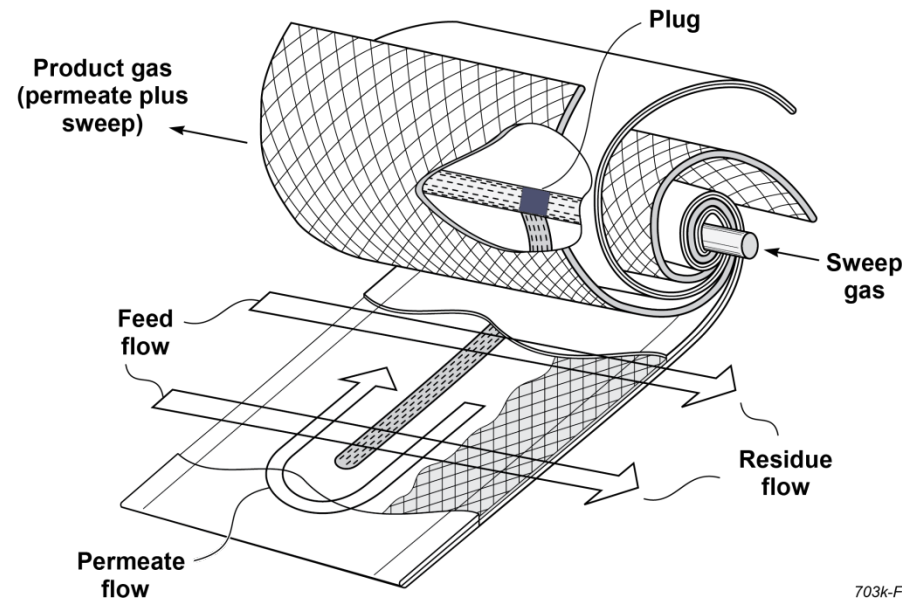


# Current Approach Uses Modified Spiral-Wound Modules

Conventional spiral-wound module



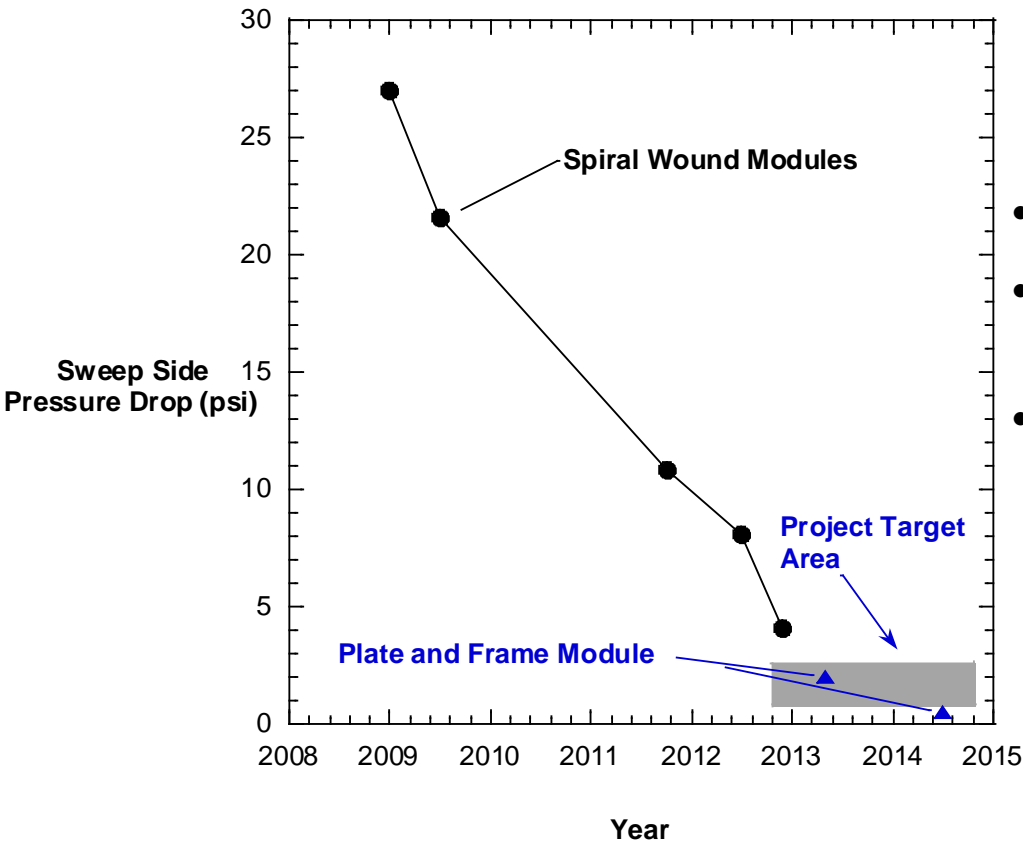
Spiral-wound countercurrent/sweep module



Each module contains 20 to 50 m<sup>2</sup> of membrane.

703K-F

# Module Pressure Drop is Key



- 1 psi = 3 MW<sub>e</sub> for a 500 MW<sub>e</sub> plant
- Best spirals still have a 4 psi pressure drop on the sweep side
- Need to develop a module for this application



# The Issues and Solutions

– Skid packing density

– Manifolding

– Footprint

Large area modules,  
compact skids

– A sweep process

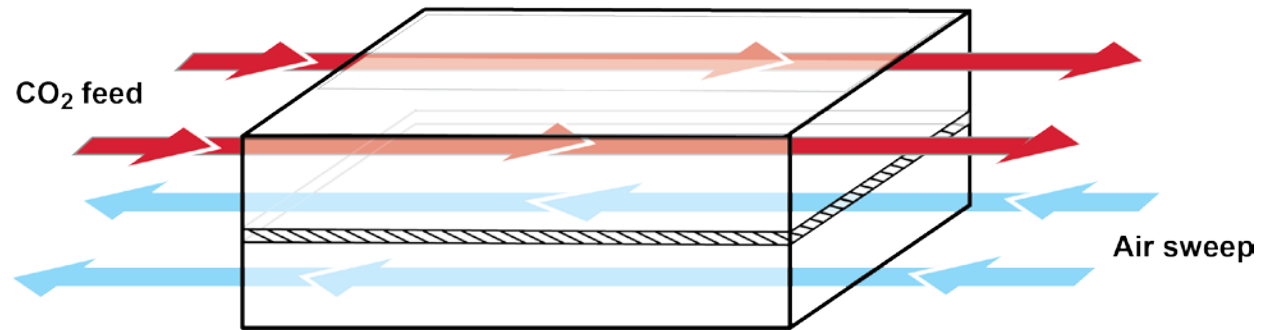
– Needs low pressure drop

Needs wide, straight  
channels on both sides  
of the membrane

# Two Membrane Contactor Designs

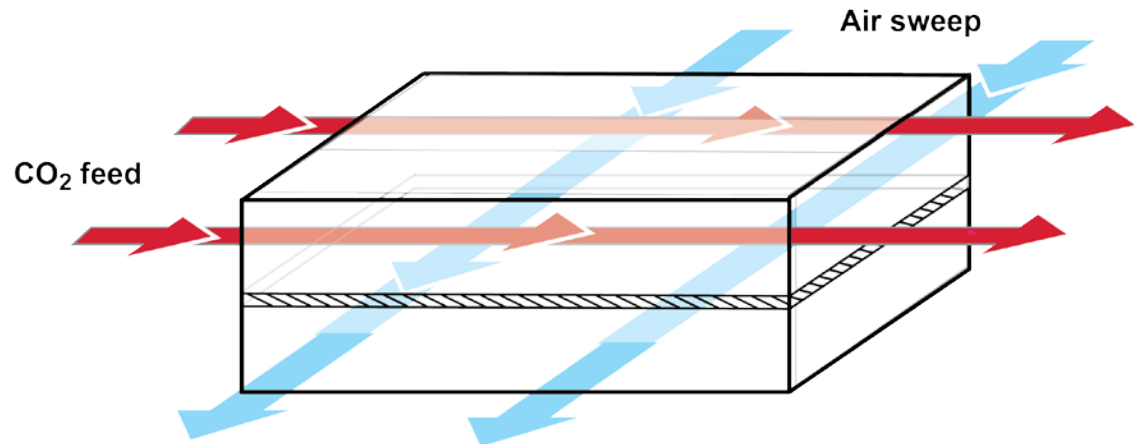
## Countercurrent

- Most efficient
- Difficult to make



## Cross-flow

- Uses 40% more membrane area
- Easier to make



# Progress to Date (DE-FE0007553)

- **BP1**

- Footprint:  
0.3 m x 0.6 m
- Modules:  
20 m<sup>2</sup>

- **BP2 and BP3**

- Footprint:  
1 m x 1 m
- Modules:  
100 m<sup>2</sup>



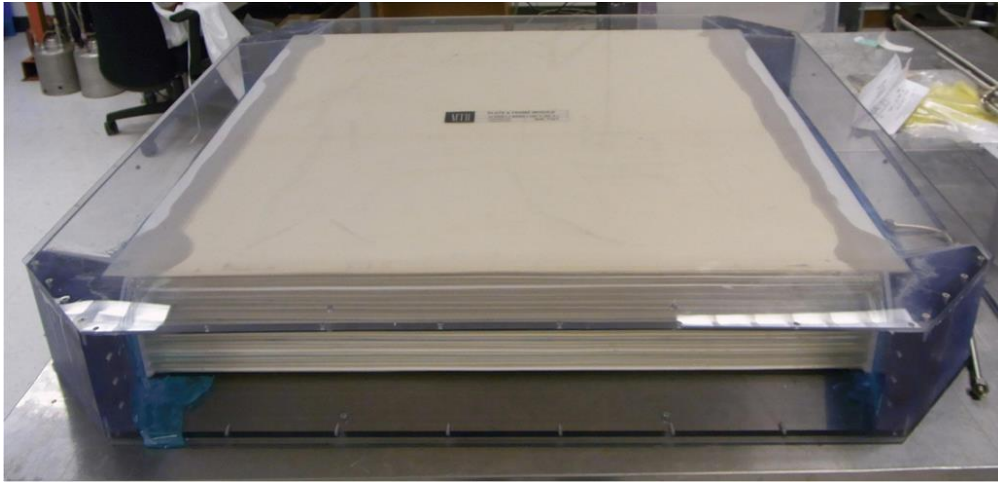
# 100 m<sup>2</sup> Membrane Module



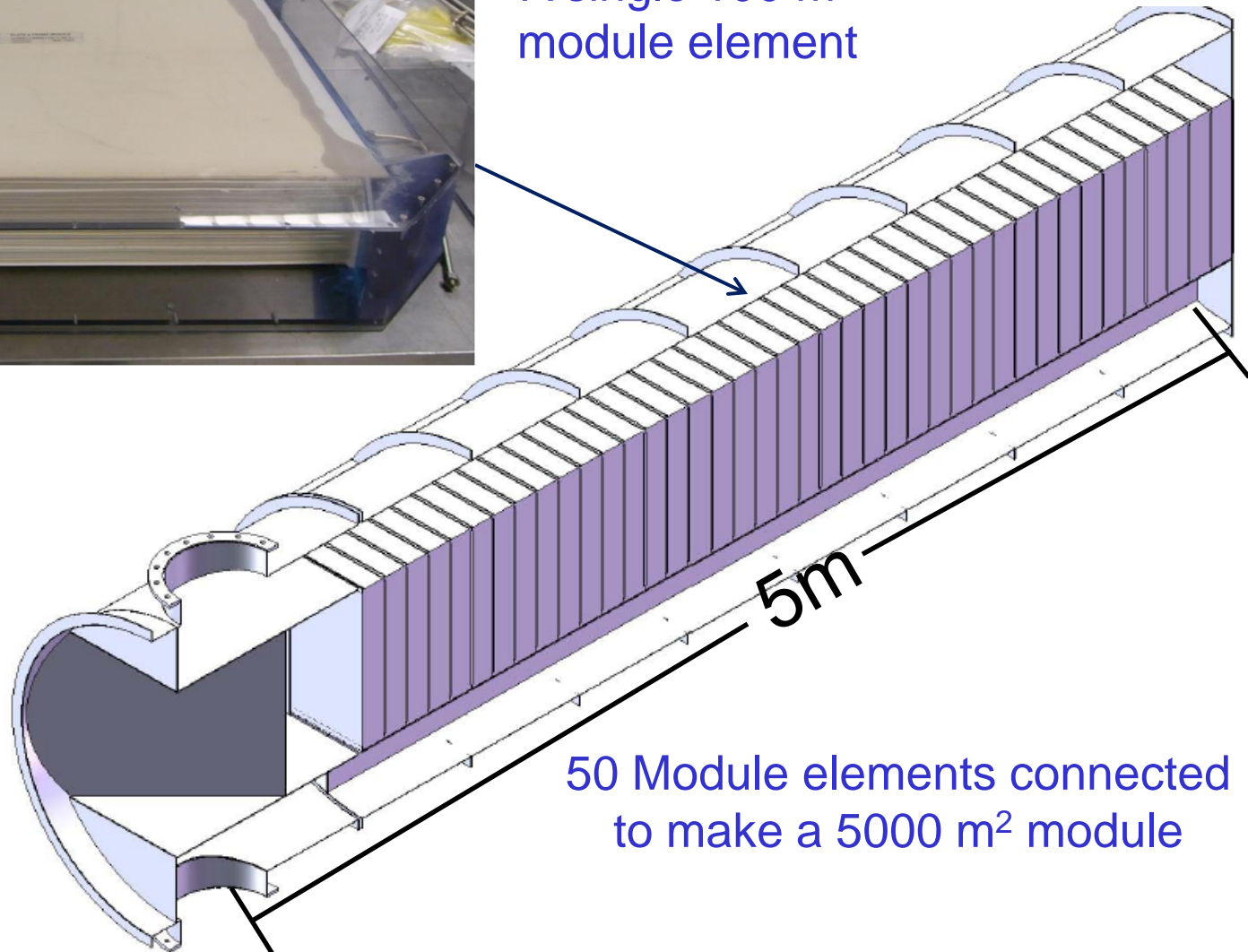
# 100 m<sup>2</sup> Membrane Module Details

- 60 – 70 individual membrane envelopes
- Weighs 100 kg completely assembled
- Has ~200 m of glue line seals (no leaks)
- Has the equivalent membrane area of 5 – 8” spiral wound membrane modules
- Sweep side pressured drop <0.5 psi

# Our Concept



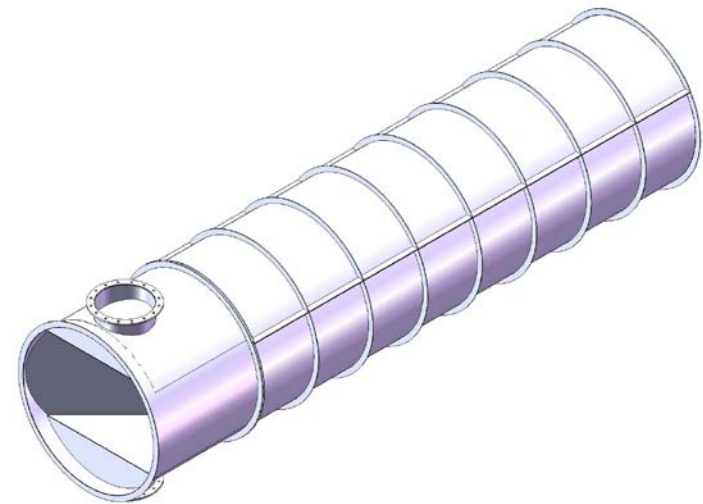
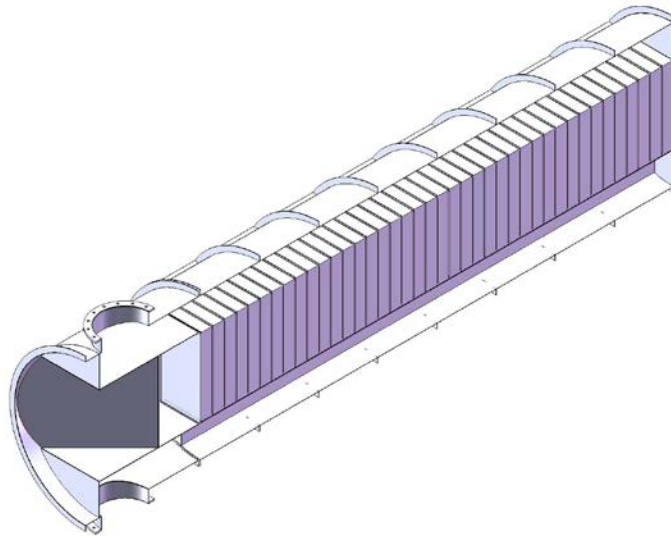
A single 100 m<sup>2</sup>  
module element



50 Module elements connected  
to make a 5000 m<sup>2</sup> module

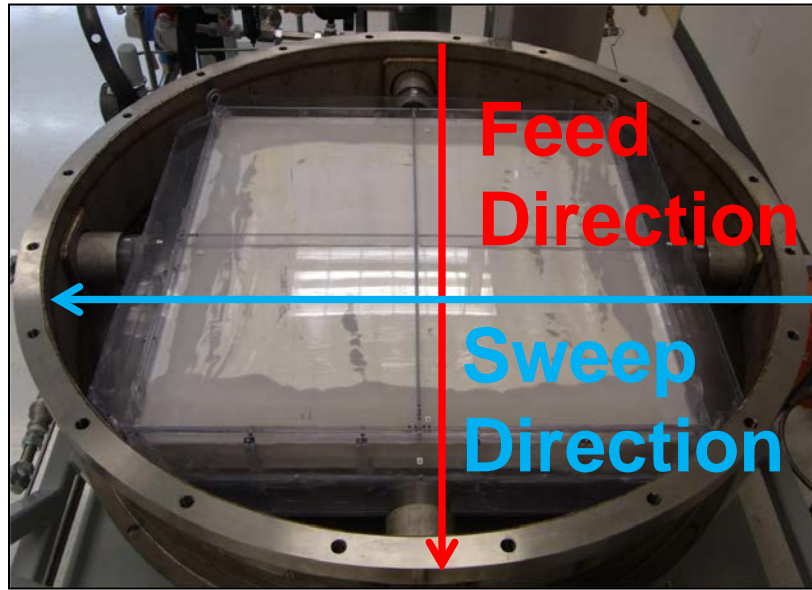
# Large-Area Plate-and-Frame Modules

Membrane	Module	Skid	Total Cost
\$20/m <sup>2</sup>	+ \$10/m <sup>2</sup>	+ \$20/m <sup>2</sup>	= \$50/m <sup>2</sup>



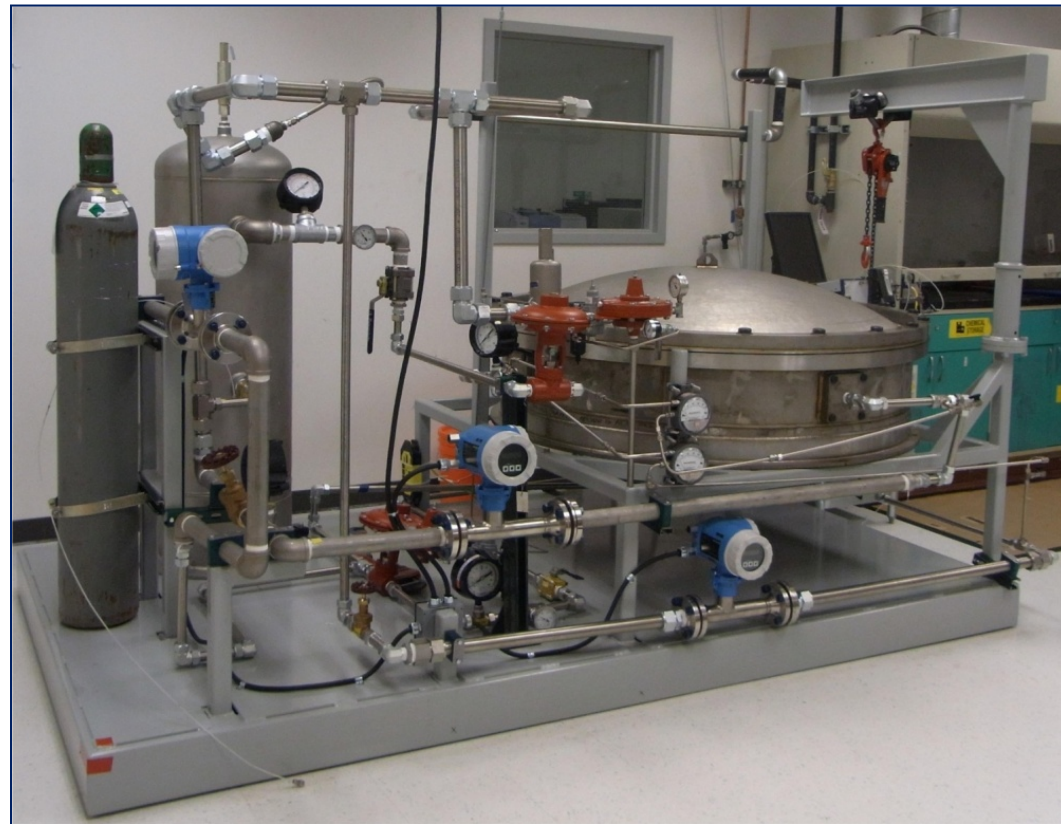
50 Module elements connected to make a 5000 m<sup>2</sup> module

# Membrane Module and Test System



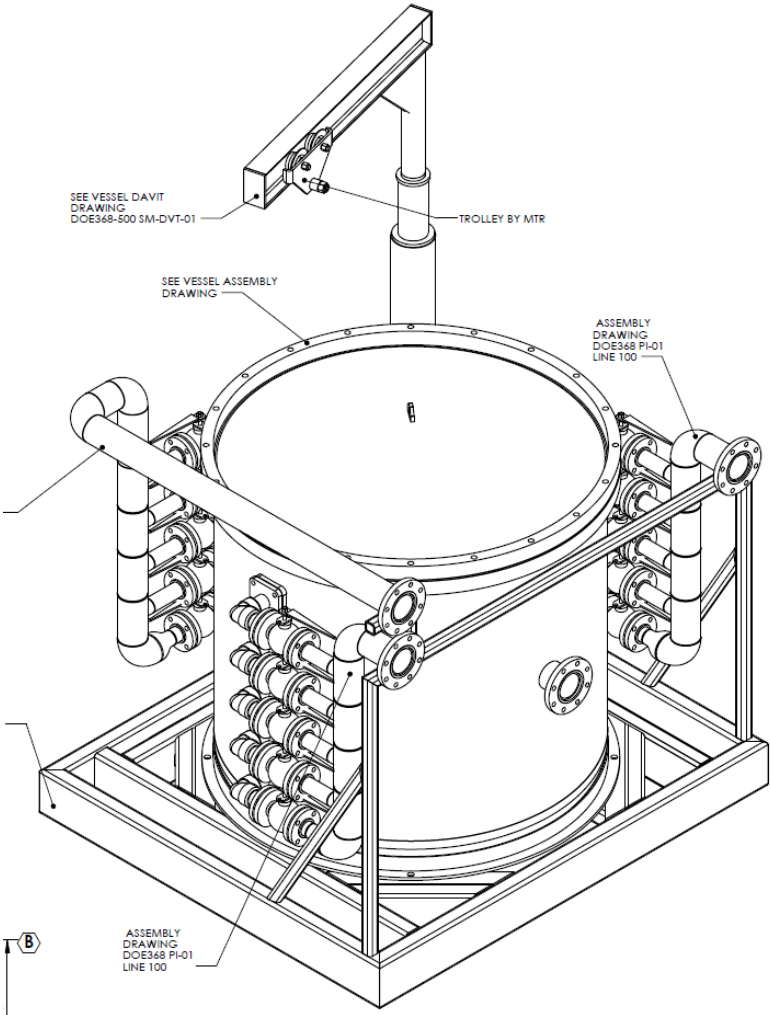
**Membrane Contactor  
with Vessel**

**Test System**

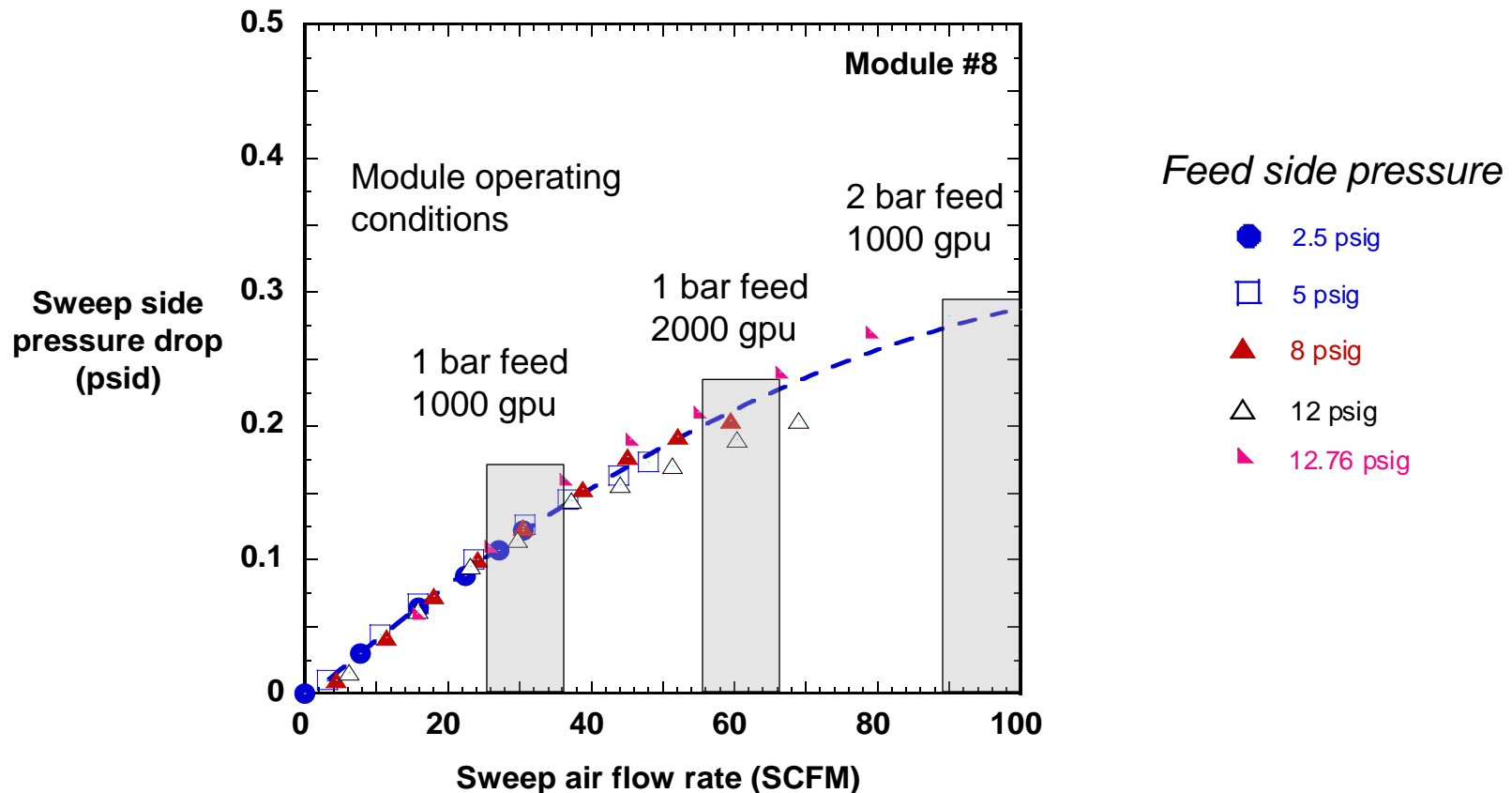




# 500 m<sup>2</sup> Skid for Testing at NCCC


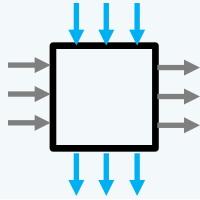
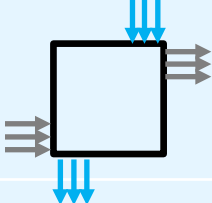
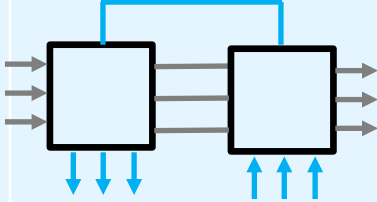


# 100 m<sup>2</sup> Module Sweep Side Pressure Drop



Sweep side air flow and pressure drop changes with membrane characteristics and operating conditions, but the effect is consistently small.

# Various Module Flow Designs

Design		Membrane area needed compared to countercurrent
Countercurrent (CC)		100%
Cross-flow (XF)		137%
Partial countercurrent		108%
Series cross-flow		126%

# What's Next

## Accomplishments to Date

- 100 m<sup>2</sup> defect free modules made
- Pressure drops reduced to < 0.5 psi.
- Five module (500 m<sup>2</sup>) skid made and ready for NCCC test.

## Next Steps

- Test five module skid at NCCC
- Scale up plan to get module skid cost to \$50/m<sup>2</sup> implemented.