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

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NETL CO_2 Capture Technology Meeting

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Membrane Technology and Research

MTR designs, manufactures, and sells membrane systems for industrial gas separations

-70 Employees
-2012 Sales: $25 million

Project Overview

- **Award name:** Low-pressure Membrane Contactors for CO_2 Capture
- **Project period:** 10/1/11 to 9/30/14
- **Funding:** $ 3.0 million DOE; $1.0 million MTR
- **DOE program manager:** Mike Mosser
- **Participants:** MTR, University of Toledo
- **Project scope:** Develop compact large membrane area (> 500 m^2), low pressure drop plate-frame sweep module for CO_2 capture application
- **Project plan:** The key project work organized by budget period is as follows:
  - BP1 : Construct prototype laboratory modules (20m^2), select components, develop fabrication technology.
  - BP2: Scale up production to 1m x 1m pilot scale modules (100m^2), demonstrate with lab test system that modules meet CO_2 separation performance and pressure drop targets.
  - BP3: Scale up to full scale module (> 500 m^2), show modules meet all performance targets. Be ready to test at NCCC.

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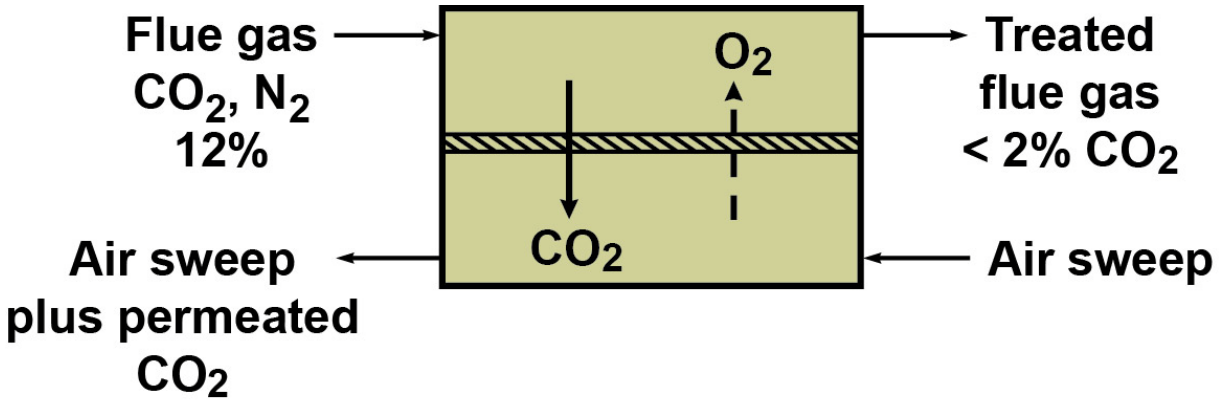
The MTR Membrane Contactor

A Way of Generating an Affordable (Partial) Pressure Difference



A separation is performed at a minimal energy cost

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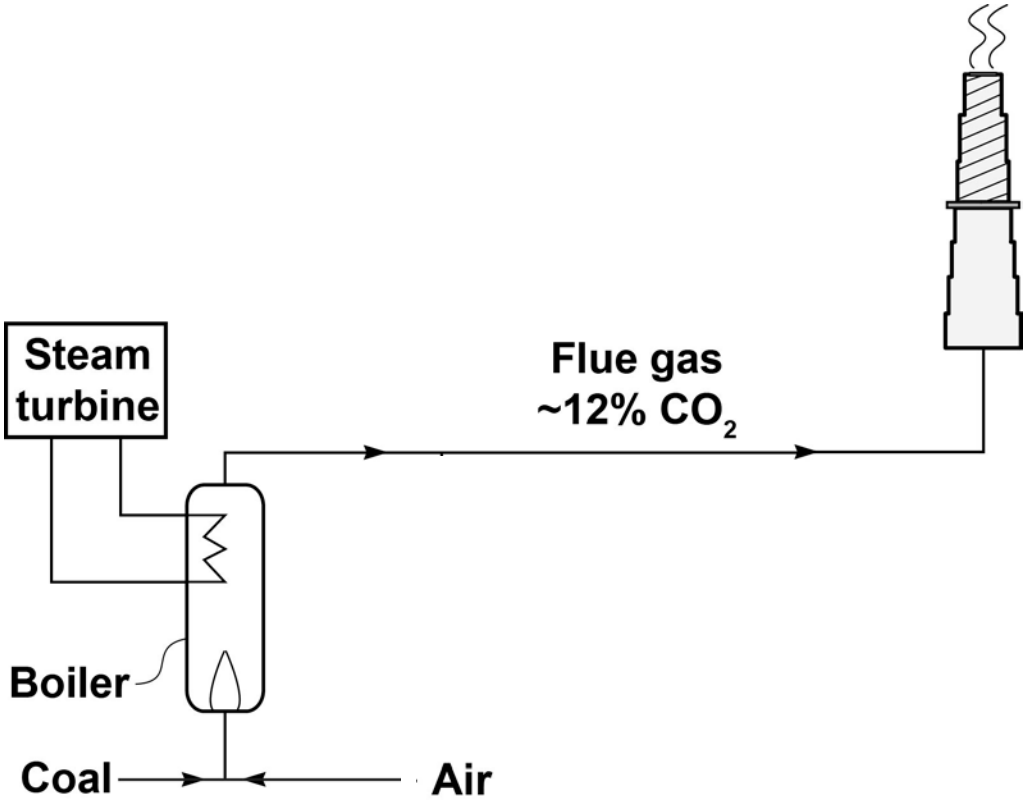
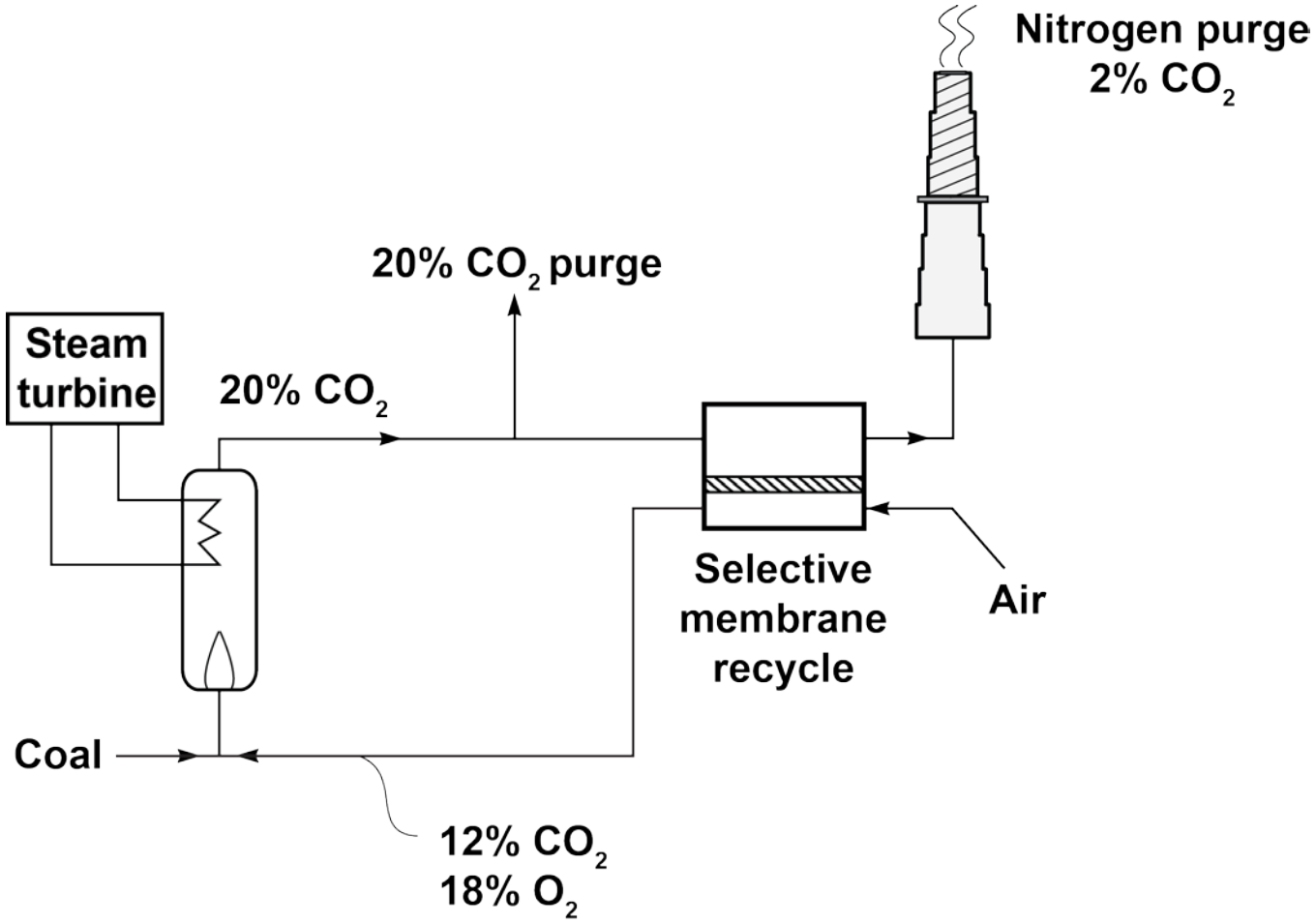
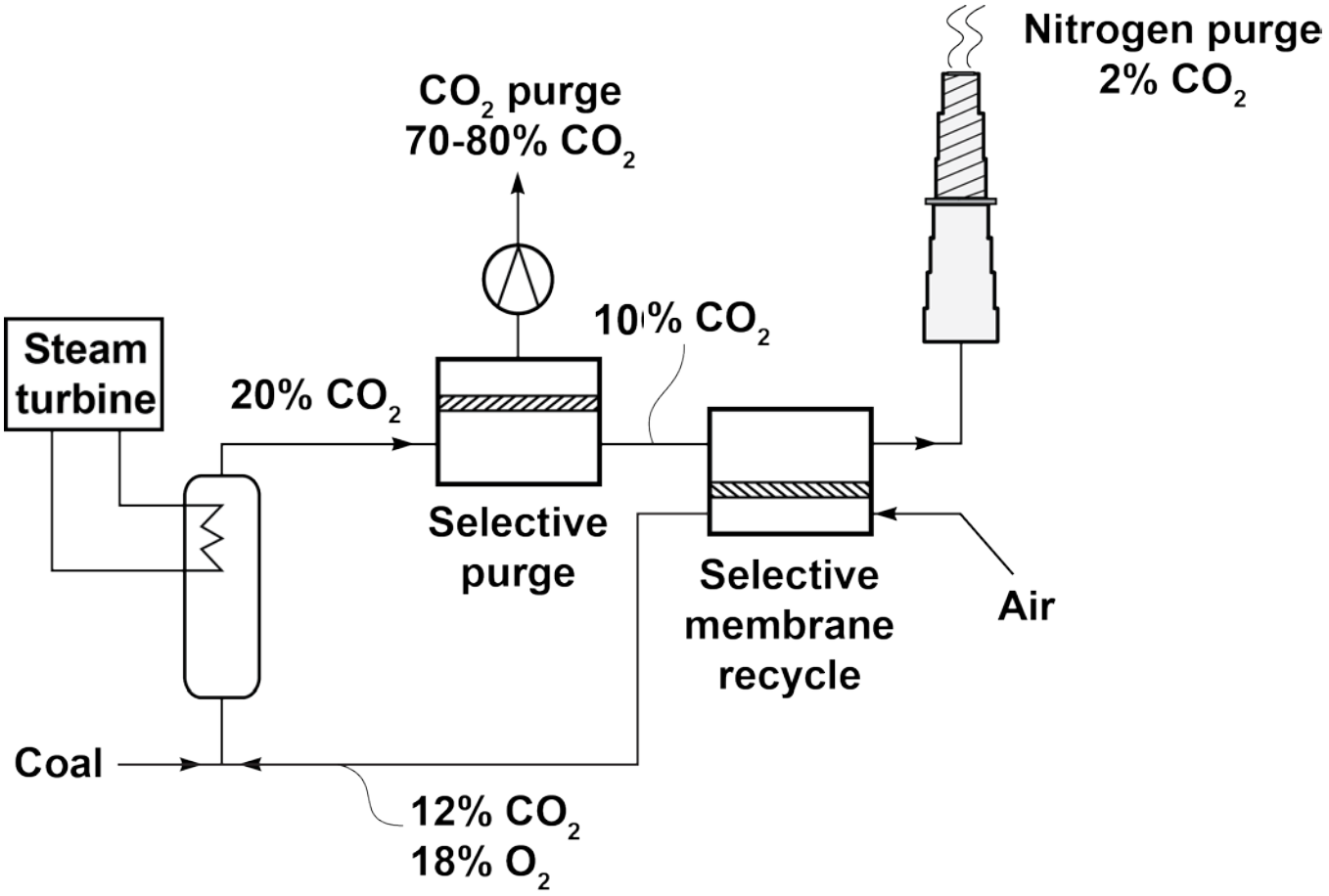
A Coal Power Plant



A Membrane CO_2 Pre-Concentrator



MTR's Membrane Solution



500 MW_e plant requires one million m^2 of membrane

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The Issues and Solutions

Membrane module area and cost are not an issue

- 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

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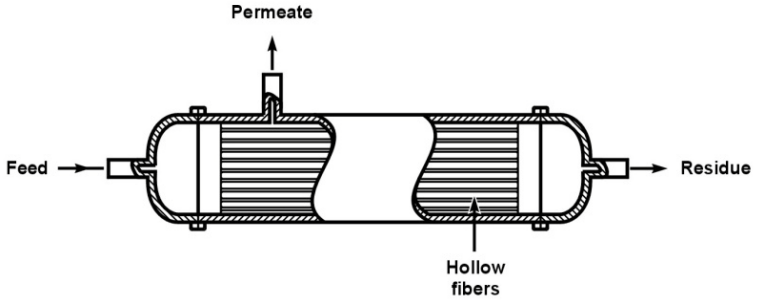
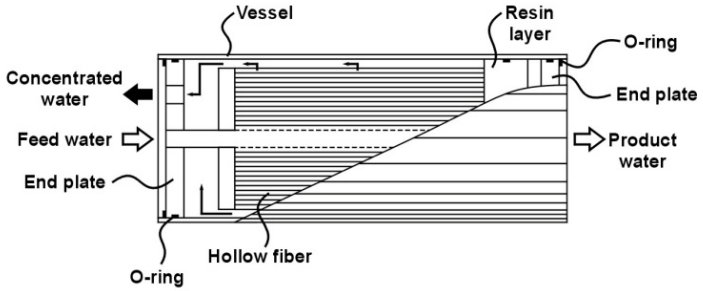
Membrane Module Designs in Current Use

Capillary Fibers



Hollow Fine Fibers



Spiral-Wound Modules

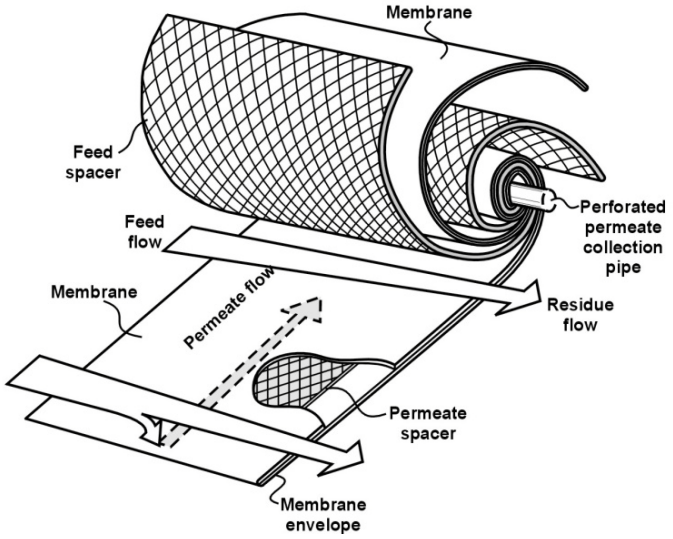
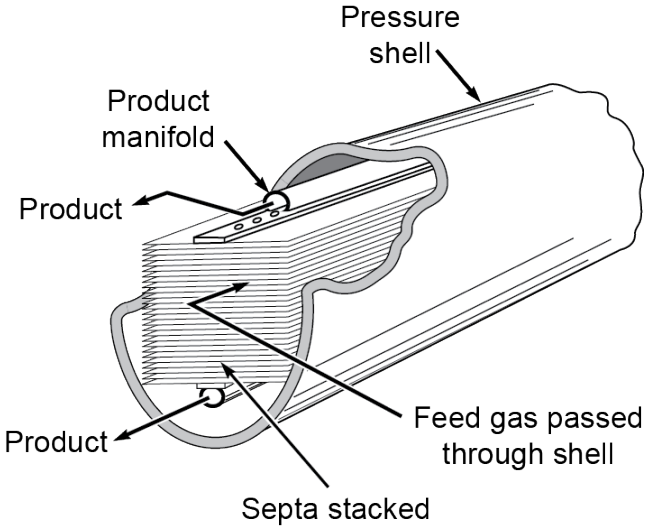


Plate-and-Frame Modules



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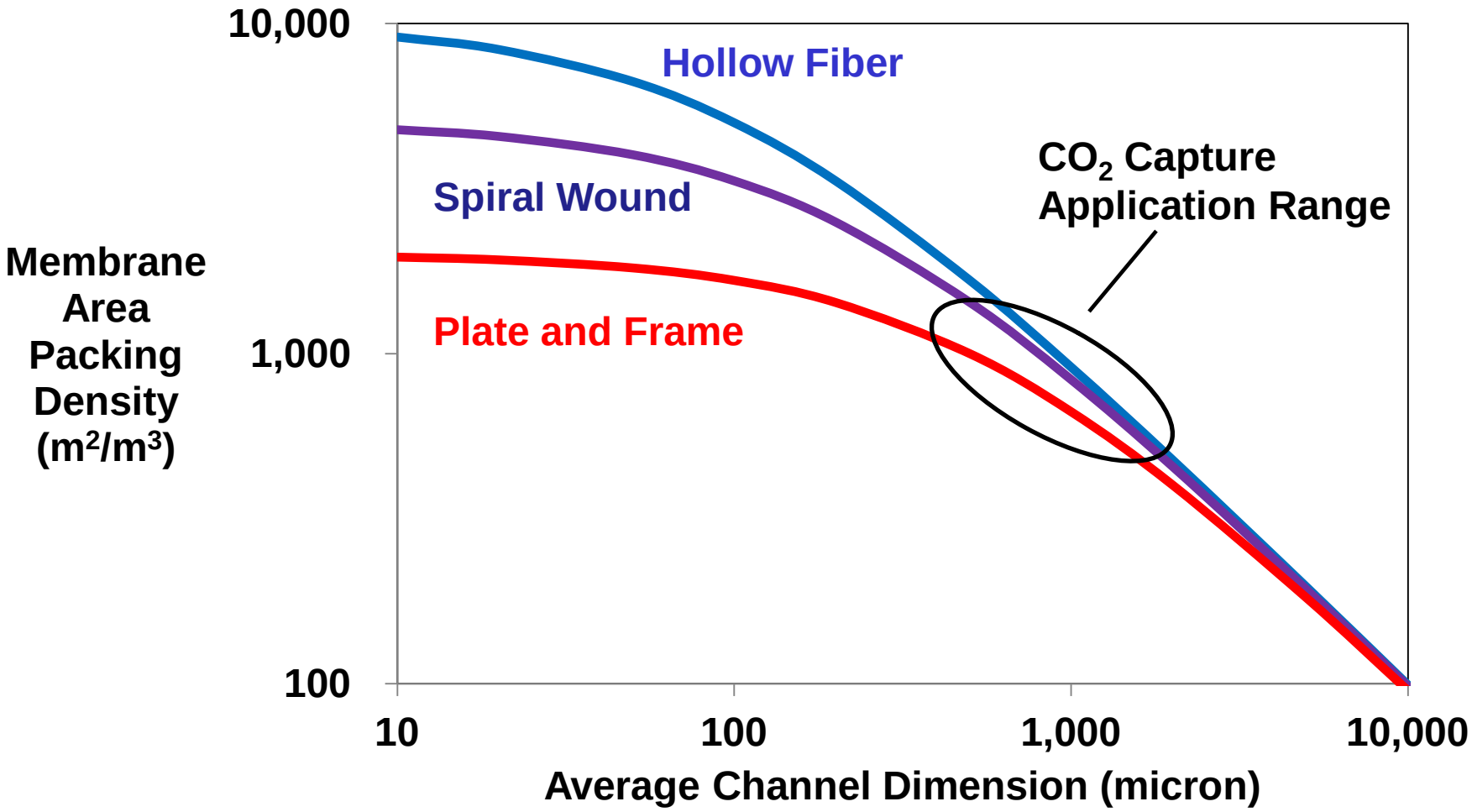
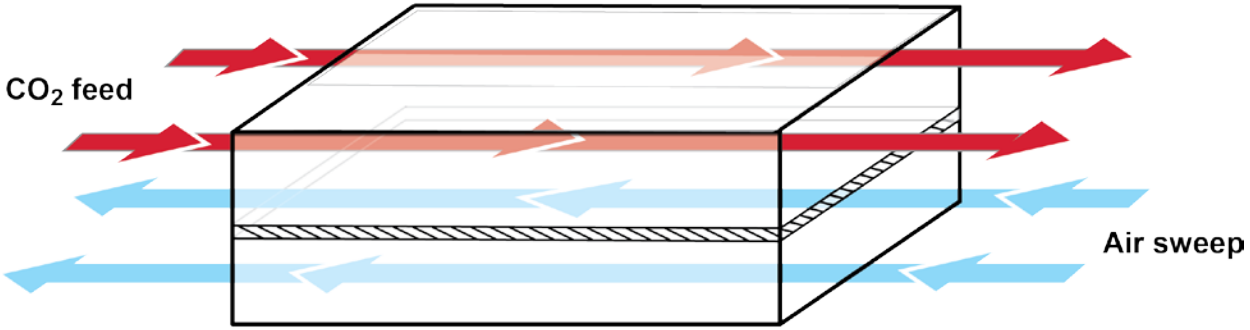
Packing Density for Different Membrane Module Configurations



Two Membrane Contactor Designs

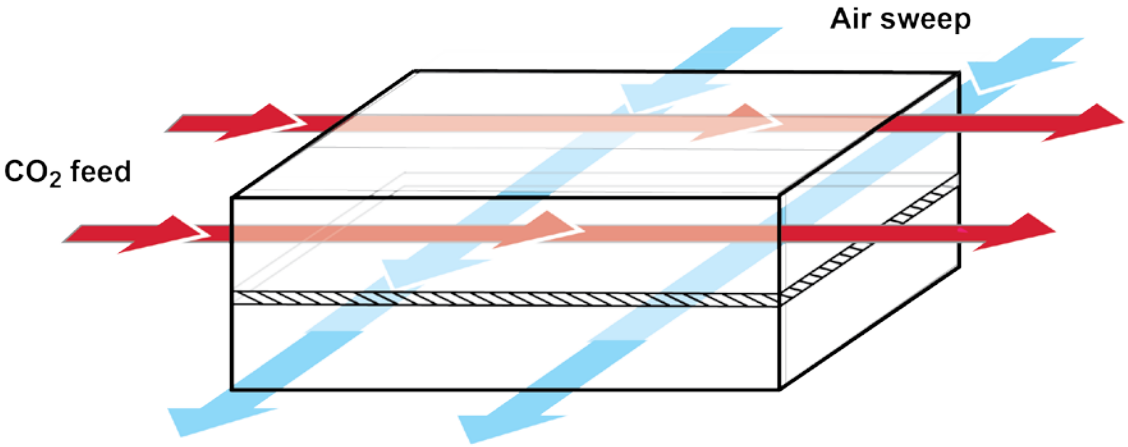
Countercurrent

- Most efficient
- Difficult to make



Cross-flow

- Uses 40% more membrane area
- Easier to make



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Progress to Date

- **Year 1**
  - Footprint: 1ft x 2 ft
  - Modules: 20 m^2
- **Year 2**
  - Footprint: 1m x 1m
  - Modules: 100 m^2

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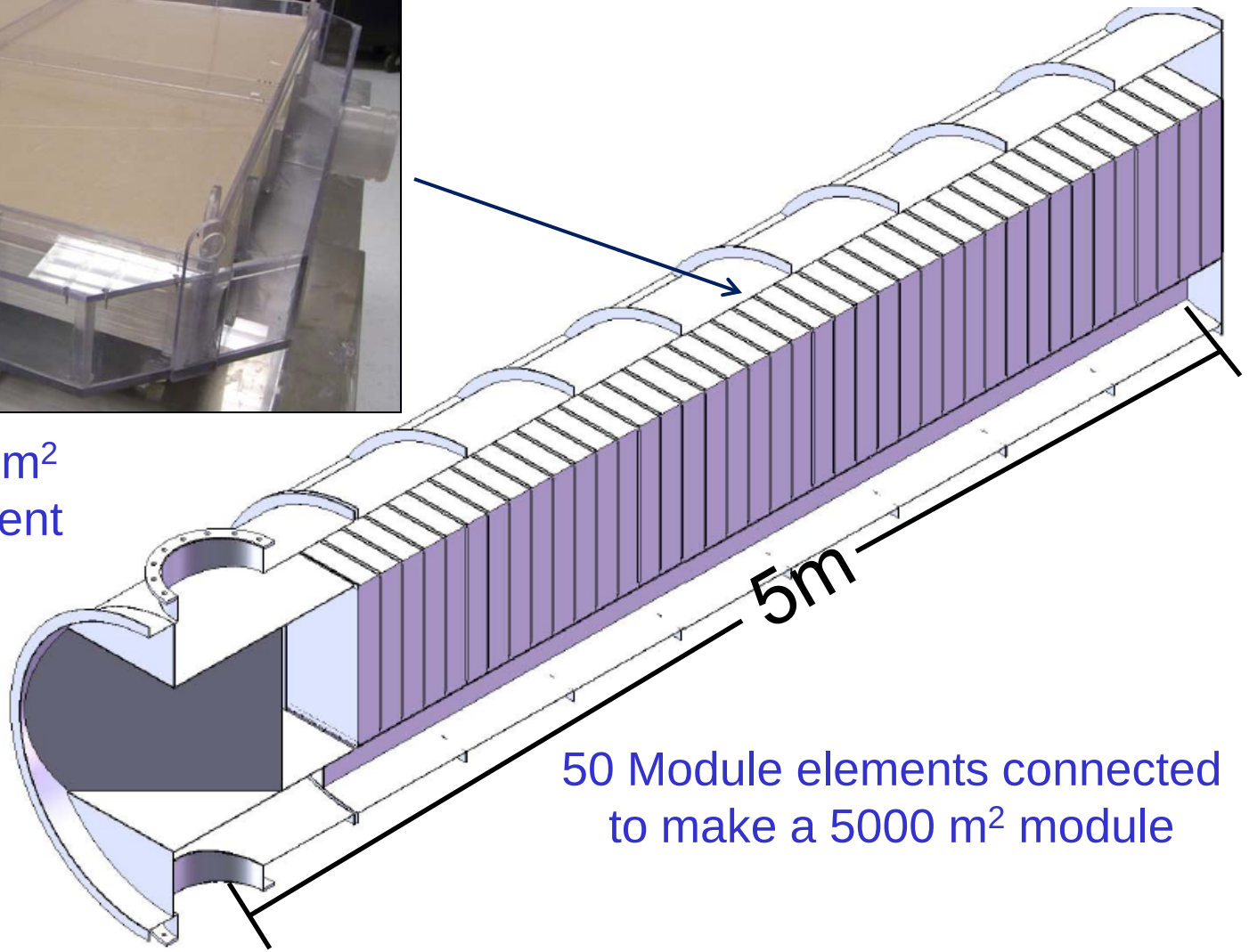
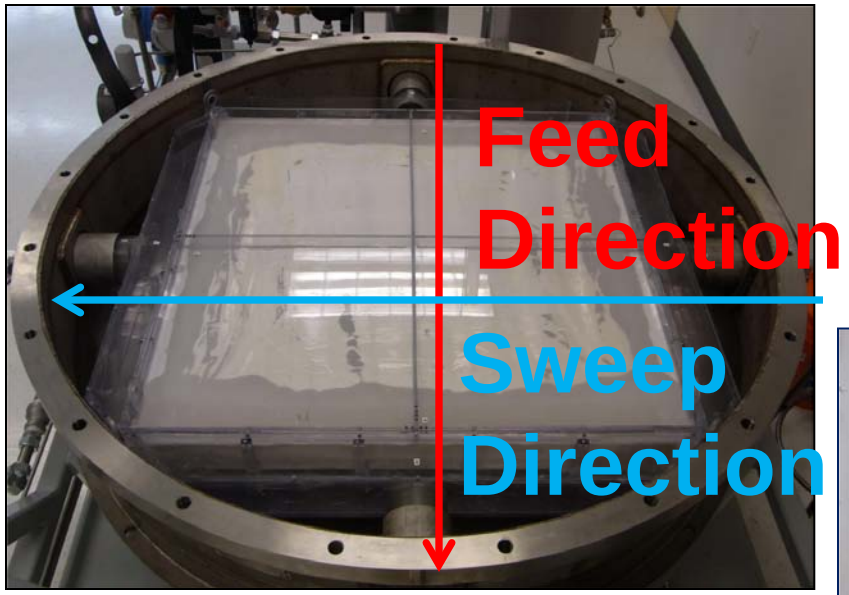
Our Concept

A single 100 m^2 module element



50 Module elements connected to make a 5000 m^2 module

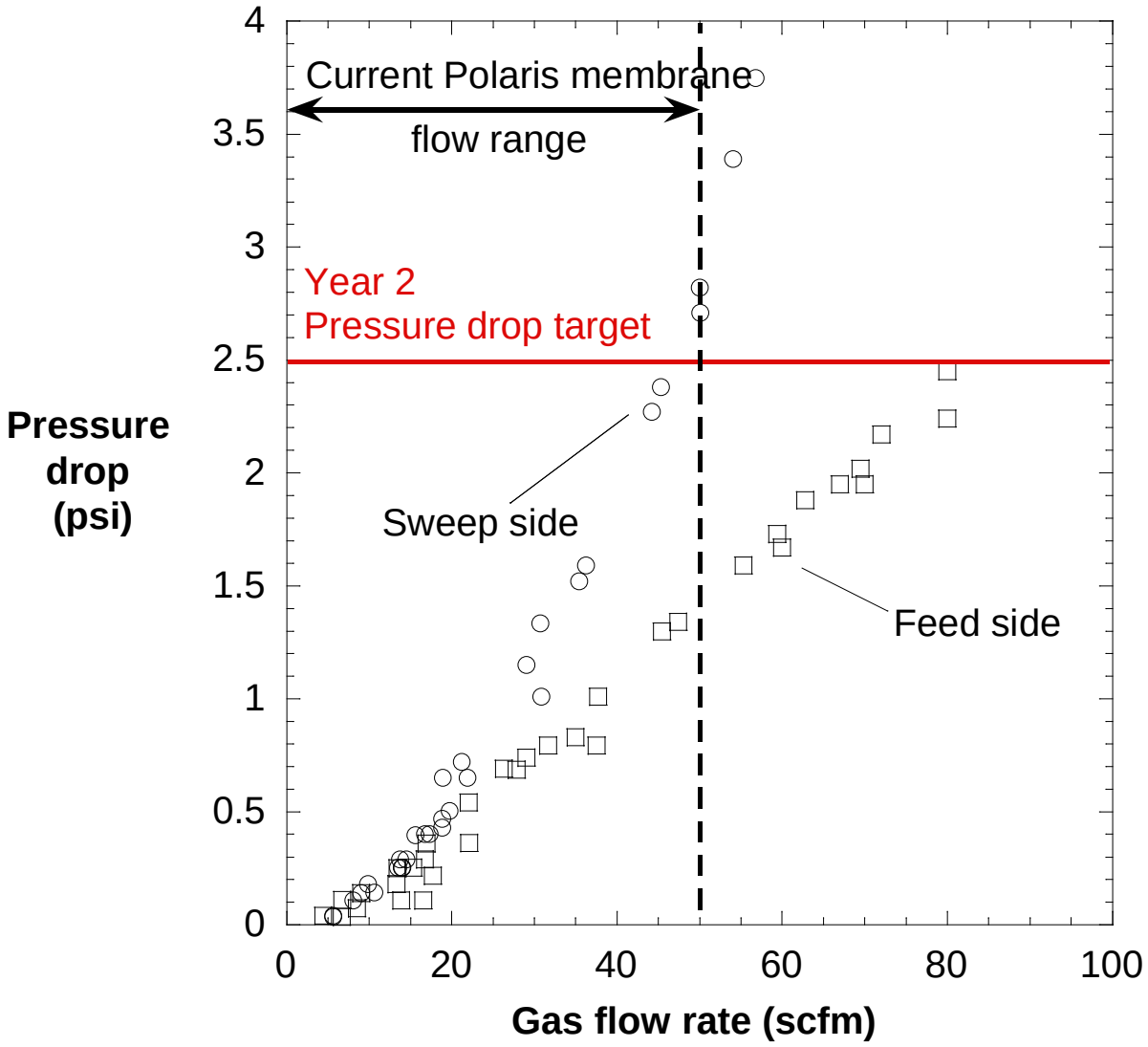
Membrane Module and Test System



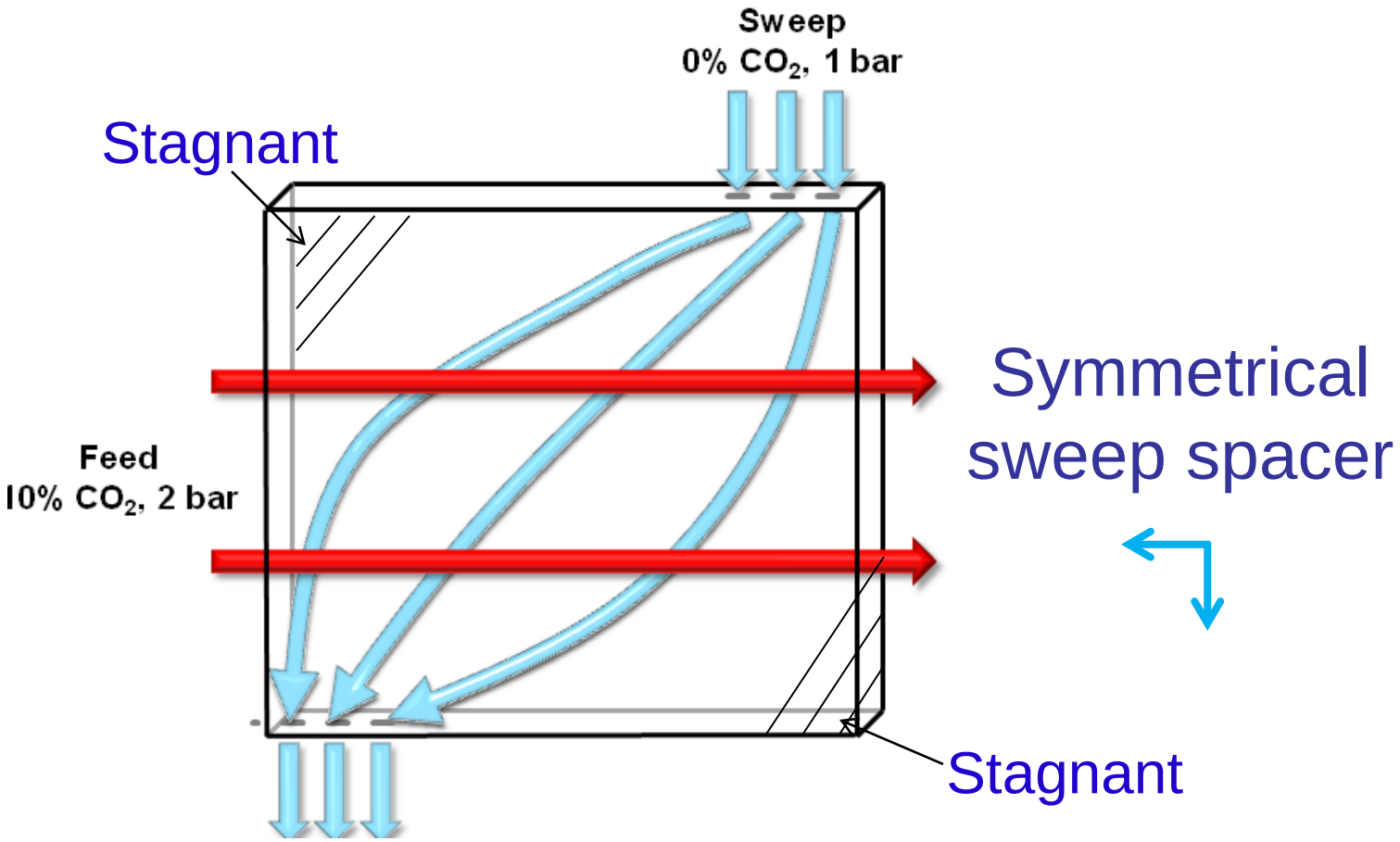
Membrane Contactor with Vessel

Test System

Module Pressure Drop within Target Range

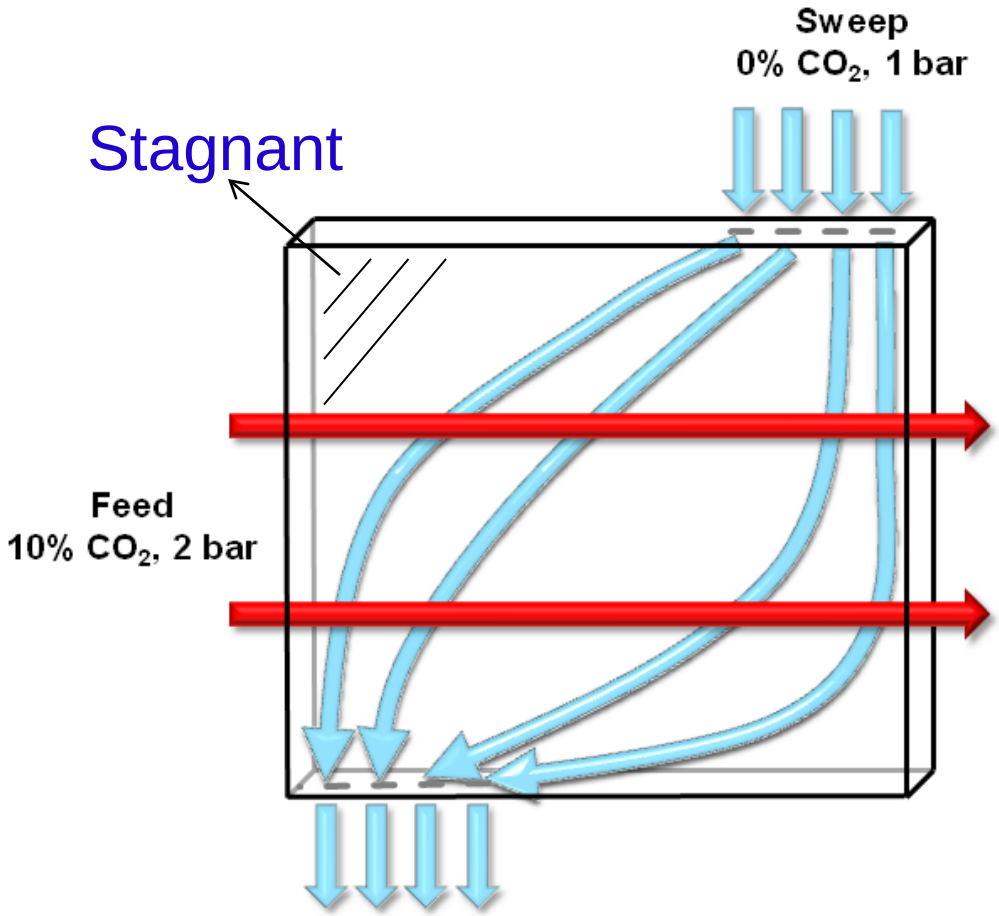


Partial Countercurrent Design



Needs **30%** more membrane compared to countercurrent

Partial Countercurrent Design



Asymmetrical sweep spacer

Needs **18%** more membrane compared to countercurrent

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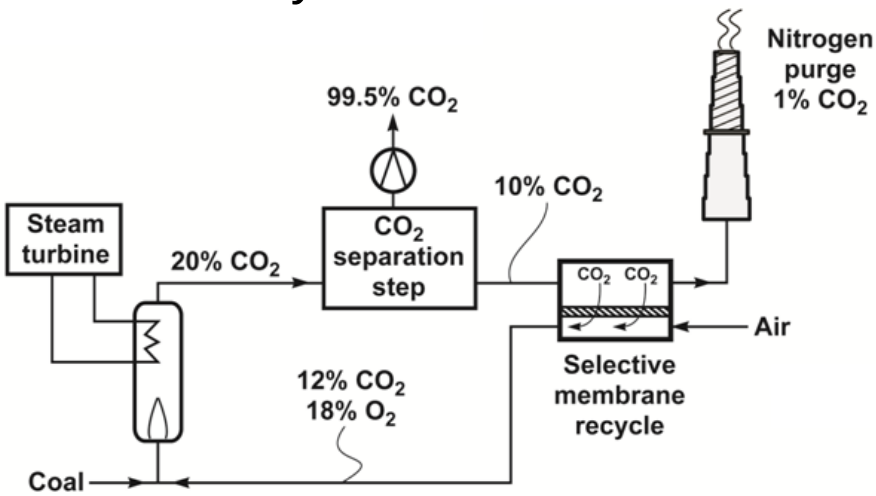
Our Plans

- Refine module fabrication techniques
- Improve module flow design
- Develop multi-element modules (3~5 elements)
- Test modules at NCCC (2014)

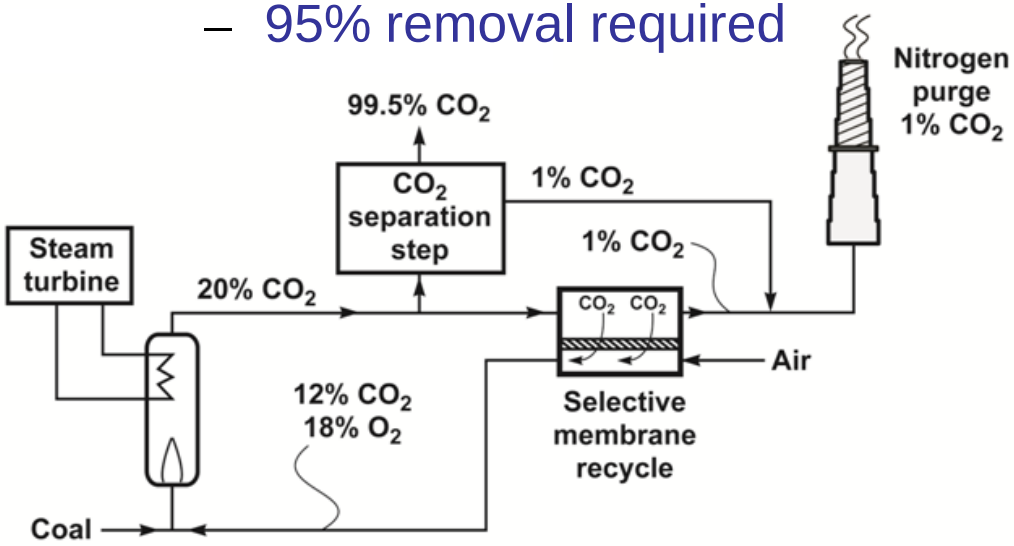
Combination Process May Be the Way to Go

Series Hybrid Case



- Double the CO_2 concentration
- 50% removal required

- Double the CO_2 concentration
- Half the flow
- 95% removal required



Parallel Hybrid Case

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