Evolution of a Concept for Regional Gathering/Processing of CO_2 Flood Recycle Streams

Paul A. Carmody
John M. Campbell Consulting

Presented at the 18th Annual CO_2 Flooding Conference

December 5-7, 2012

Midland, Texas

Status of EOR Reinjection/Processing

- Currently you are “on your own” when processing CO_2 EOR flood produced gas
- Limited regional gathering and processing options exist
- Most fields have their own equipment on site

Potential Regional Gathering/Processing

- Thesis:
  - Regional gathering/processing of produced gas from CO_2 EOR floods is feasible and potentially the best choice for field development
- *This is to be accomplished by:*
  - *In-field use of membranes and reinjection of CO_2 followed by,*
  - *Dense phase gathering of enriched gas to a,*
  - *Central plant with high recovery of all products.*

Put yourself in the shoes a company planning to develop a CO_2 flood

- Once you evaluated the field and have procured CO_2,
- And figured how to separate the oil and water from the produced gas,
- You need to do something with the gas.
- Of course. It will be reinjected.
- But Wait!
- The engineering firm informs you that 12% to 20% of the liquids are about to be reinjected along with the gas.
- “No problem” smiles the process engineer. “Just …”

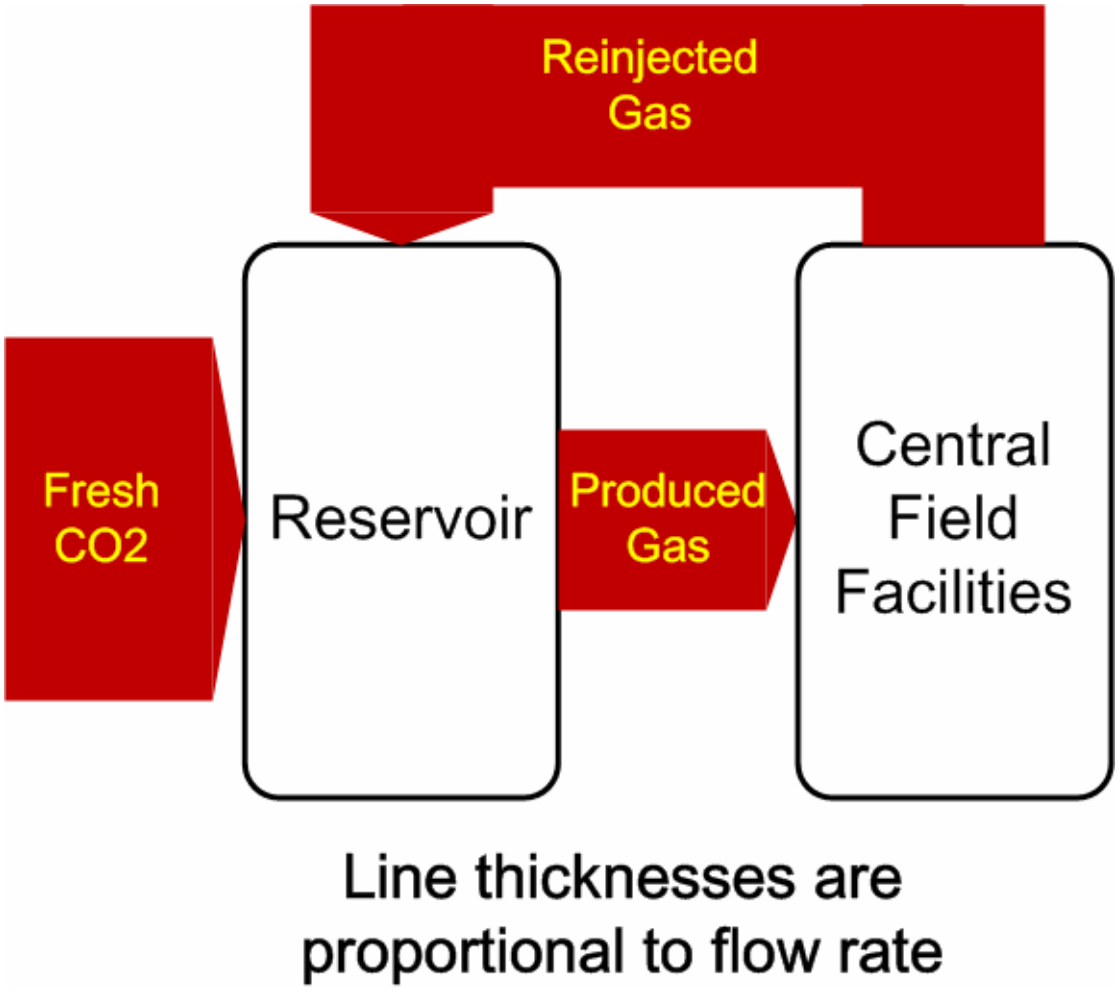
“Install a CO_2 Processing Plant”

- One could be forgiven for thinking that this is a refinery
- Another look at reinjection vs. processing is needed

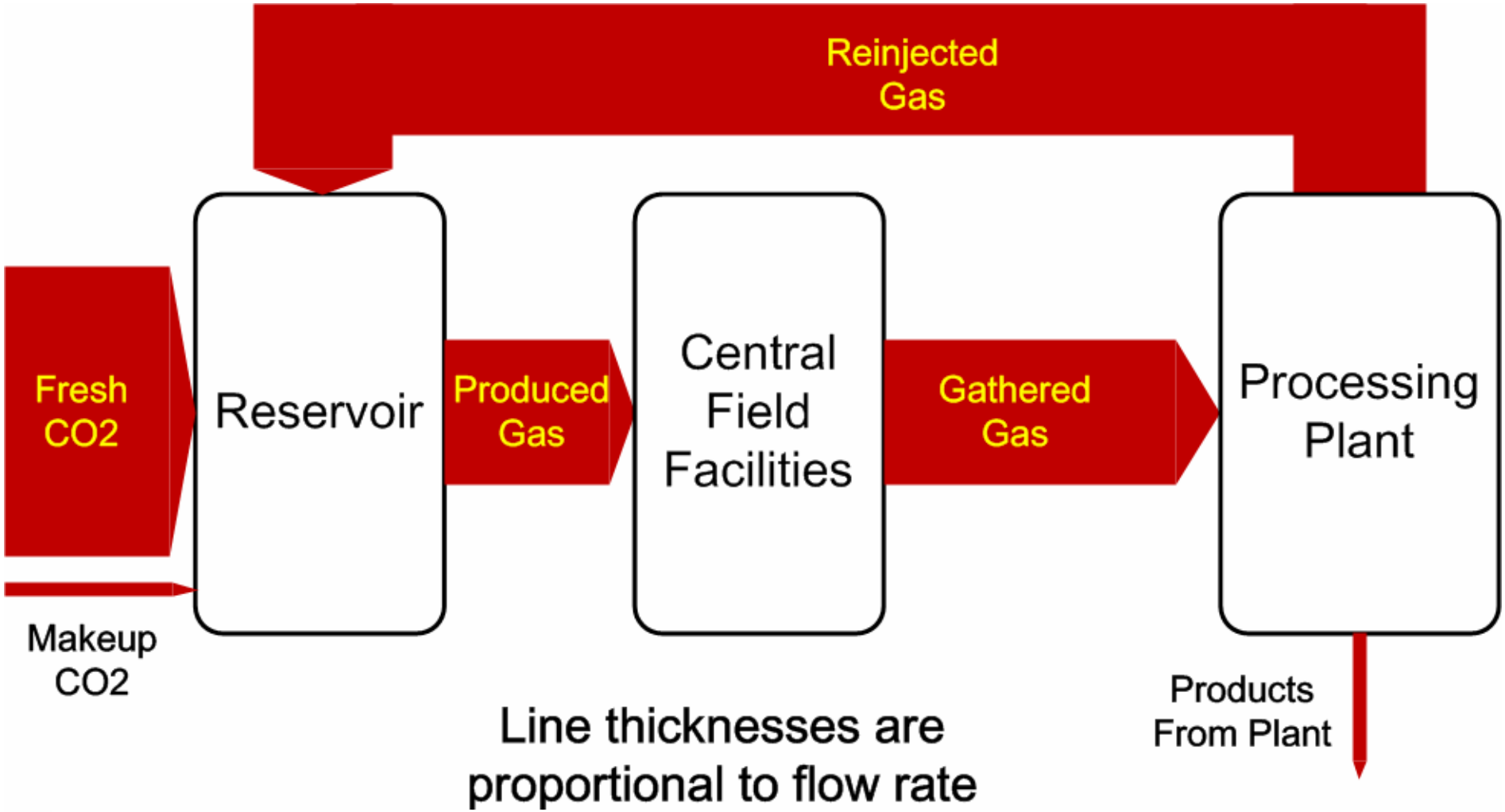
Reinjection vs. Processing

- Reinjection:
  - It is the simplest means of handling CO_2 flood produced gas
  - But there is no recovery of products
  - Many operators reinject gas rather than process it
- Processing (with reinjection)
  - Complex, high cost, high opex, high energy
  - Natural gas recovery and deeper NGL recoveries cost more

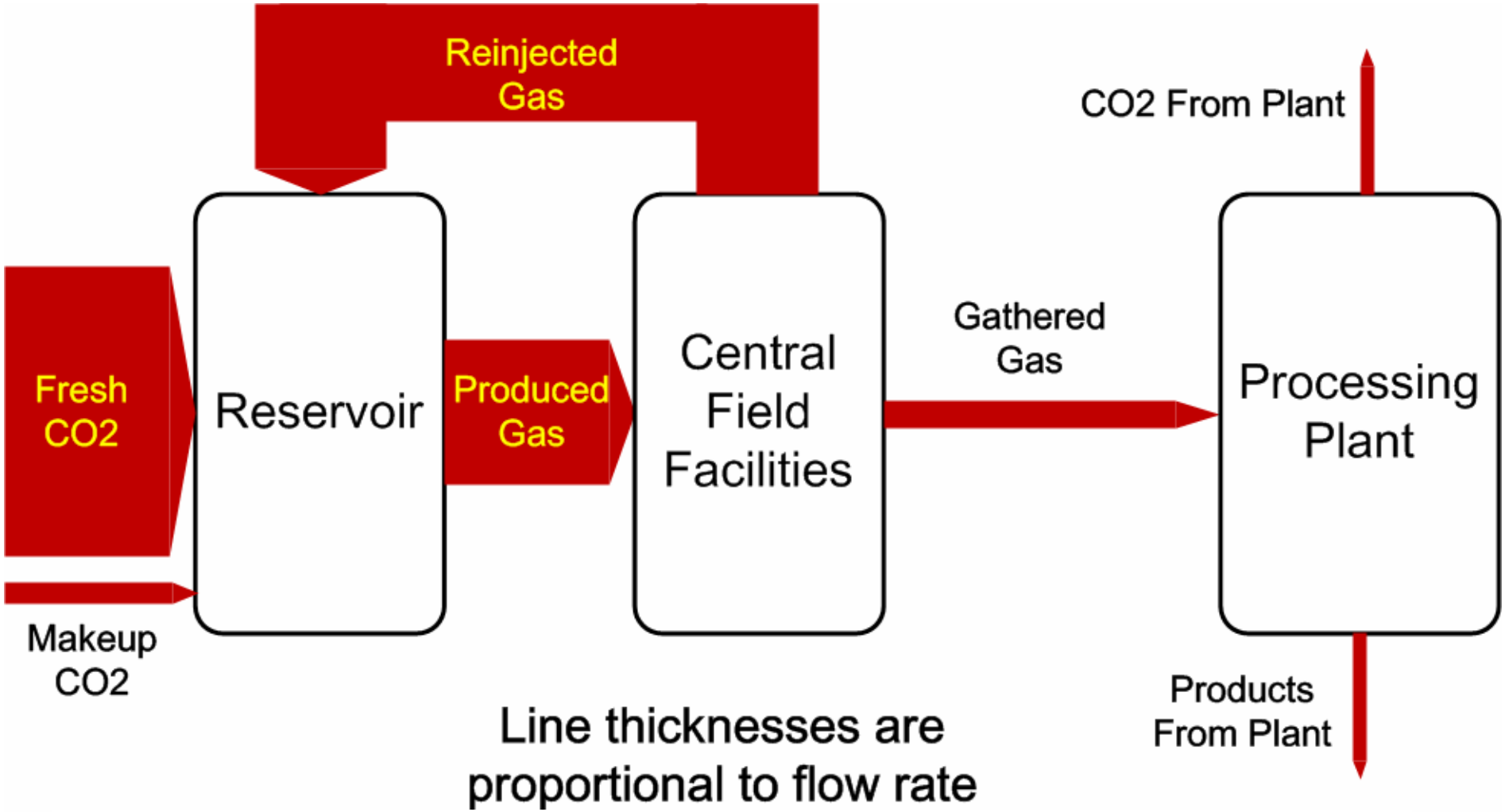
Option 1 - Reinjection



Option 2 – Gathering and Processing

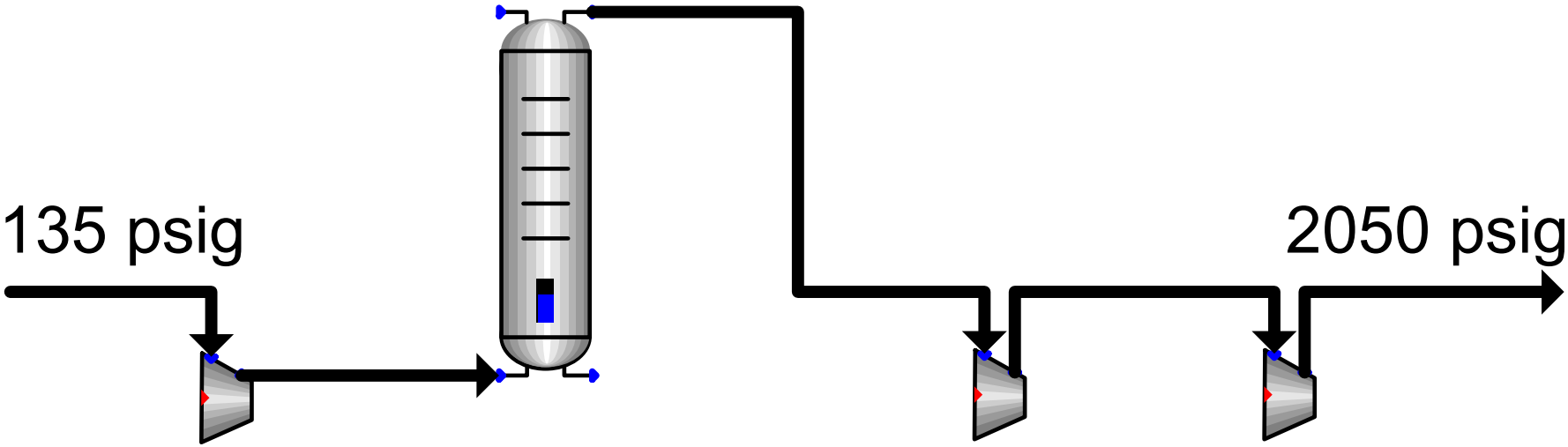


Future Option - Membrane Enrichment, Gathering, and Processing



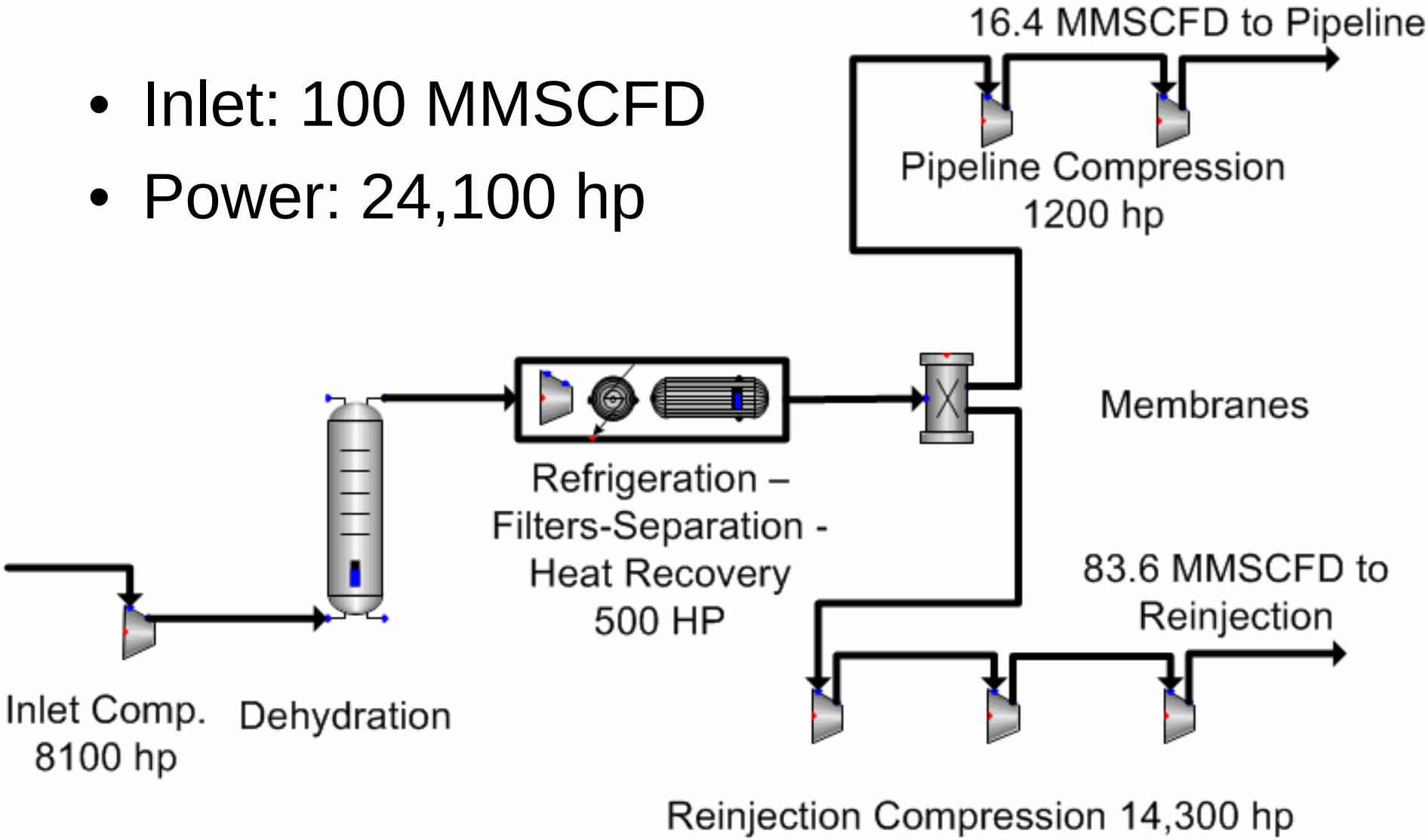
Reinjection

- Inlet: 100 MMSCFD; 90% CO_2
- Power: 16,100 hp



Membrane Enrichment

- Inlet: 100 MMSCFD
- Power: 24,100 hp



Membrane Skid

- One skid with 42 tubes is shown
- 100 MMSCFD facility would use three skids

Membrane Enrichment Facility

- Facility with four skids of membrane tubes

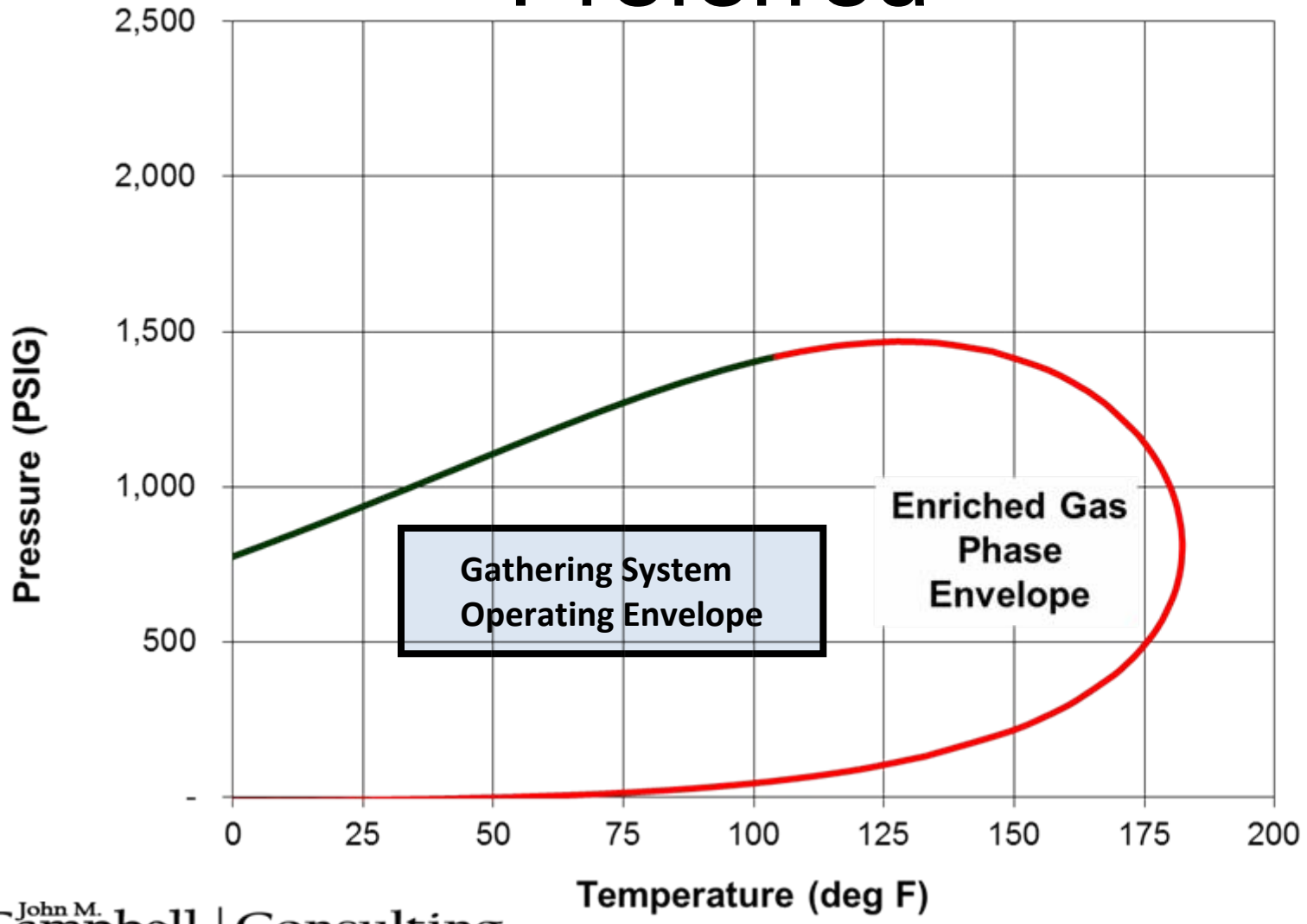
Recoveries – 100 MMSCFD

	Produced Gas	Re-injection	Gas Gathered to Plant			
			Pipeline Gas	Recovery	NGL gpm	NGL bbl/d
CO2	90.0%	97.4%	52.3%	**9%**		
H2S	0.5%	0.5%	0.3%	11%		
Nitogen	0.4%	0.1%	1.7%	75%		
Methane	4.7%	1.6%	20.5%	72%		
Ethane	1.9%	0.3%	10.0%	86%	2.68	730
Propane	1.1%	0.1%	6.2%	91%	1.72	670
Butanes	0.7%	0.0%	4.2%	98%	1.34	520
Pentanes+	0.8%	0.0%	4.7%	99%	1.88	730
Totals	100.0%	100.0%	100.0%	16%	7.62	**2650**
BTU/cuft	166	29	872			
Fuel Gas MDTKH/D						**3.38**
Plant Recovery of Ethane				70%		

Pipeline Impacts of Enriching Gas

- Gathering 50 miles from a 100 MMSCFD field at 67 deg F requires the following:
  - No enrichment:
    - 20” gathering line at 740 psig, 9.6 #/cuft
    - 10” CO_2 return line at 2000 psig, 57.1 #/cuft
  - Enrichment:
    - 10” gathering line at 740 psig, 9.5 #/cuft
    - 6” gathering line at 2000 psig, 36.0 #/cuft
      - Single phase gathering (no slug catcher)

Dense Phase Gathering Preferred



Other Benefits

- Reservoir: Removal of light ends minimizes MMP
- Pipeline: Increase capacity through use of pumps
- Plant –
  - Lower CO_2 concentration into plant:
    - Recovery of ethane will be greater
    - Flares will not require added fuel
  - Reduced flow rate results in:
    - Smaller equipment including vessels and columns
    - Reduced pump and compression power
    - Lower heating and cooling duties
  - Dense phase saves refrigeration due to inlet JT

Implementation of Enriched Gathering and Processing

- Opportunities from existing fields that are currently reinjecting produced gas
- Greater opportunities come from a potential renaissance of CO_2 EOR
  - Drivers include:
    - High oil prices
    - Low gas prices
    - Development of further CO_2 sources

Thank You!

- Acknowledgement
  - ProSep:
    - Provided membrane performance calculations
    - Pictures of membranes