Acid Gas Removal Options for Minimizing Methane Emissions

Lessons Learned from Natural Gas STAR

Processors Technology Transfer Workshop

Gas Processors Association,
Devon Energy, Enogex,
Dynegy Midstream Services and
EPA's Natural Gas STAR Program

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Acid Gas Removal: Agenda

- Methane Losses
- Methane Recovery
- Is Recovery Profitable?
- Industry Experience
- Discussion Questions

Methane Losses from Acid Gas Removal

- There are 291 acid gas removal (AGR) units in gas processing plants[1]
  - **Emit 646 MMcf annually[1]**
  - **6 Mcf/day emitted by average AGR unit[1]**
  - **Most AGR units use diethanol amine (DEA) process or Selexol™ process**
  - **Several new processes have recently been introduced to the gas processing industry**

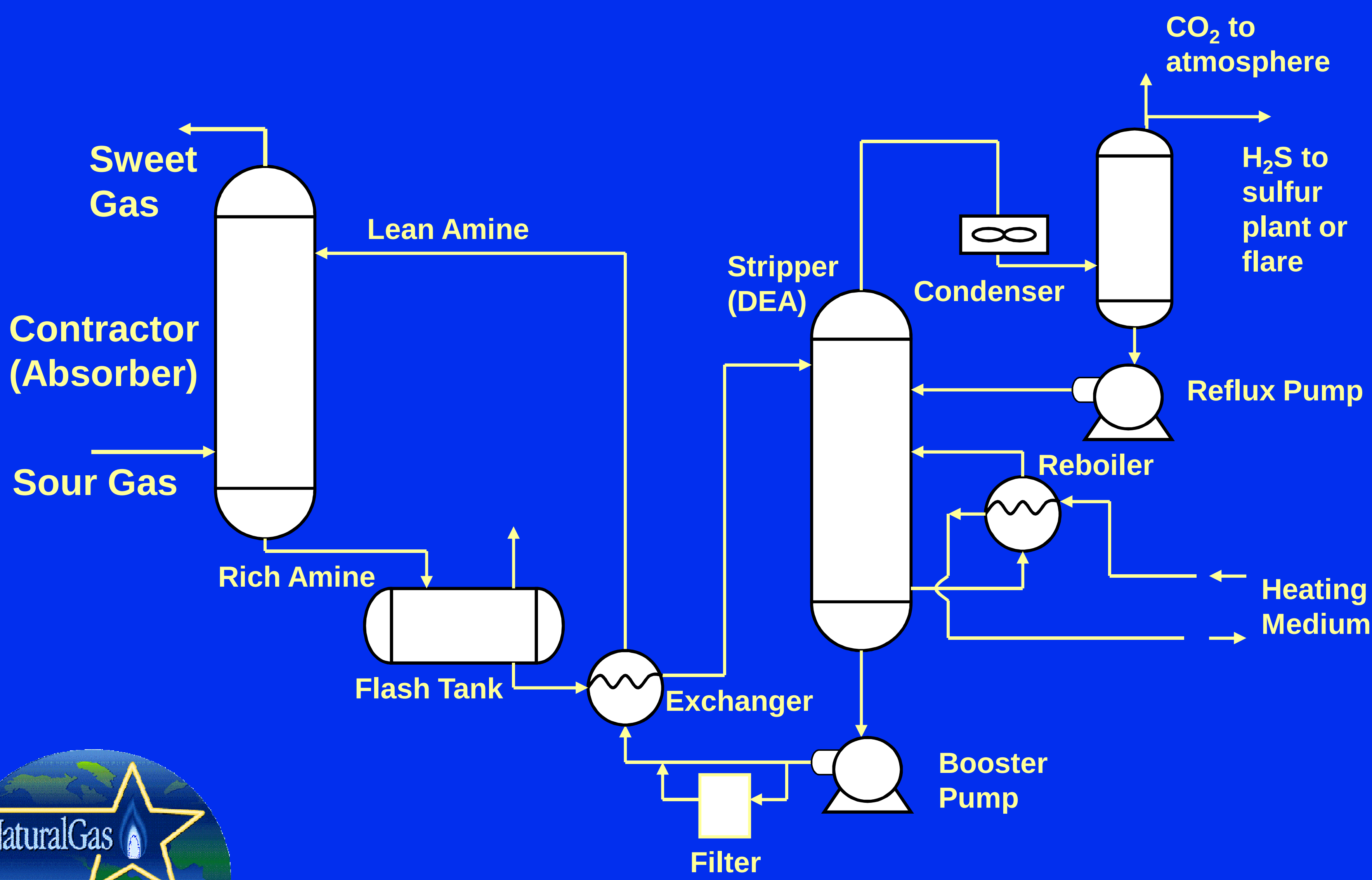
[1]Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2002

What is the Problem?

- 1/3 of U.S. gas reserves contain CO_2 and/or N_2[1]
- Wellhead natural gas may contain acid gases
  - **H_2S, CO_2, are corrosive to gathering/boosting and transmission lines, compressors, pneumatic instruments and distribution equipment**
- Acid gas removal processes have traditionally used DEA to absorb acid gas
- DEA regeneration strips acid gas (and absorbed methane)
  - **CO_2 (with methane) is typically vented to the atmosphere**
  - **H_2S is typically flared or sent to sulfur recovery**

[1]www.engelhard.com/documents/GPApaper2002.pdf

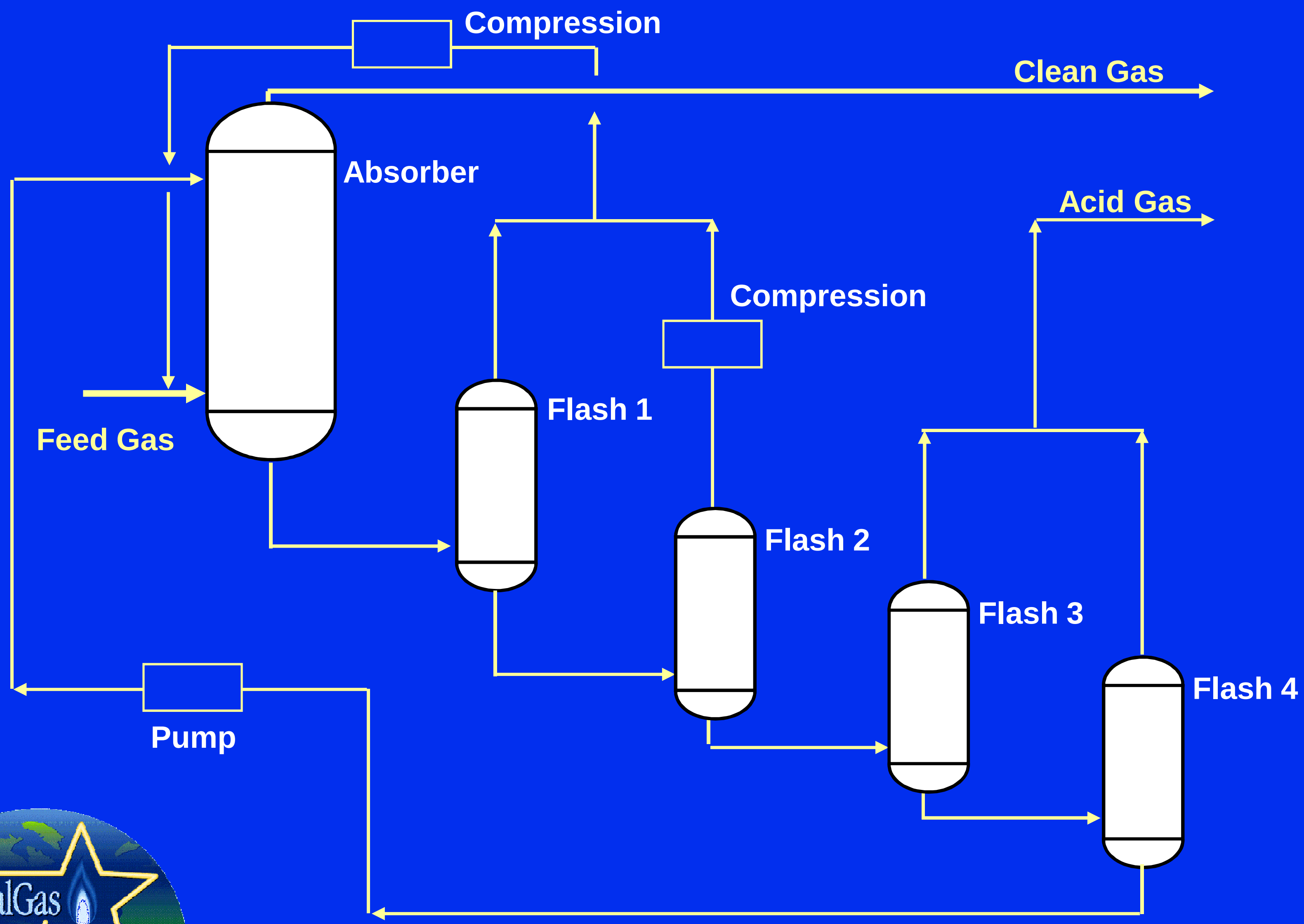
Typical Amine Process



Methane Recovery - New Acid Gas Removal Technologies

- GTI & Uhde Morphysorb® Process
- Engelhard Molecular Gate® Process
- Kvaerner Membrane Process
- Primary driver is process economics, not methane emissions savings
- Reduce methane venting by 50 to 100%

Morphysorb® Process



Morphysorb® Process

- Morphysorb® absorbs acid gas but also absorbs some methane
  - **Methane absorbed is 66% to 75% lower than competing solvents[1]**
- Flash vessels 1 & 2 recycled to absorber inlet to minimize methane losses
- Flash vessels 3 & 4 at lower pressure to remove acid gas and regenerate Morphysorb®

[1]Oil and Gas Journal, July 12, 2004, p57

Is Recovery Profitable?

- Morphysorb® can process streams with high (>10%) acid gas composition
- 30% to 40% Morphysorb® operating cost advantage over DEA or Selexol™ [2]
  - **66% to 75% less methane absorbed than DEA or Selexol™**
  - **About 33% less THC absorbed[2]**
  - **Lower solvent circulation volumes**
- At least 25% capital cost advantage from smaller contactor and recycles[2]
- Flash recycles 1 & 2 recover ~80% of methane that is absorbed[1]

[1]Oil and Gas Journal, July 12, 2004, p57, Fig. 7

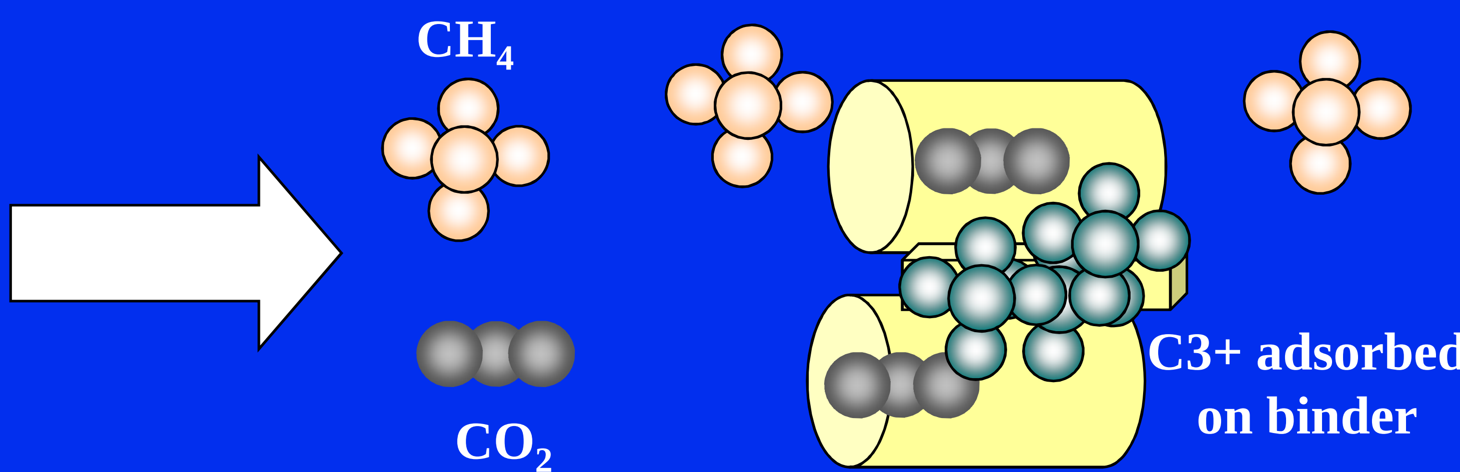
[2]GTI

Industry Experience - Duke Energy

- Kwoen plant does not produce pipeline-spec gas
  - **Separates acid gas and reinjects it in reservoir**
  - **Frees gathering and processing capacity further downstream**
- Morpysorb® used in process unit designed for other solvent
- Morphysorb® chosen for acid gas selectivity over methane
  - **Less recycle volumes; reduced compressor horsepower**

Methane Recovery - Molecular Gate® CO_2 Removal

- Adsorbs acid gas contaminants in fixed bed
- Molecular sieve application selectively adsorbs acid gas molecules of smaller diameter than methane
- Bed regenerated by depressuring
  - **5% to 10% of feed methane lost in "tail gas" depressuring**
  - **Route tail gas to fuel**



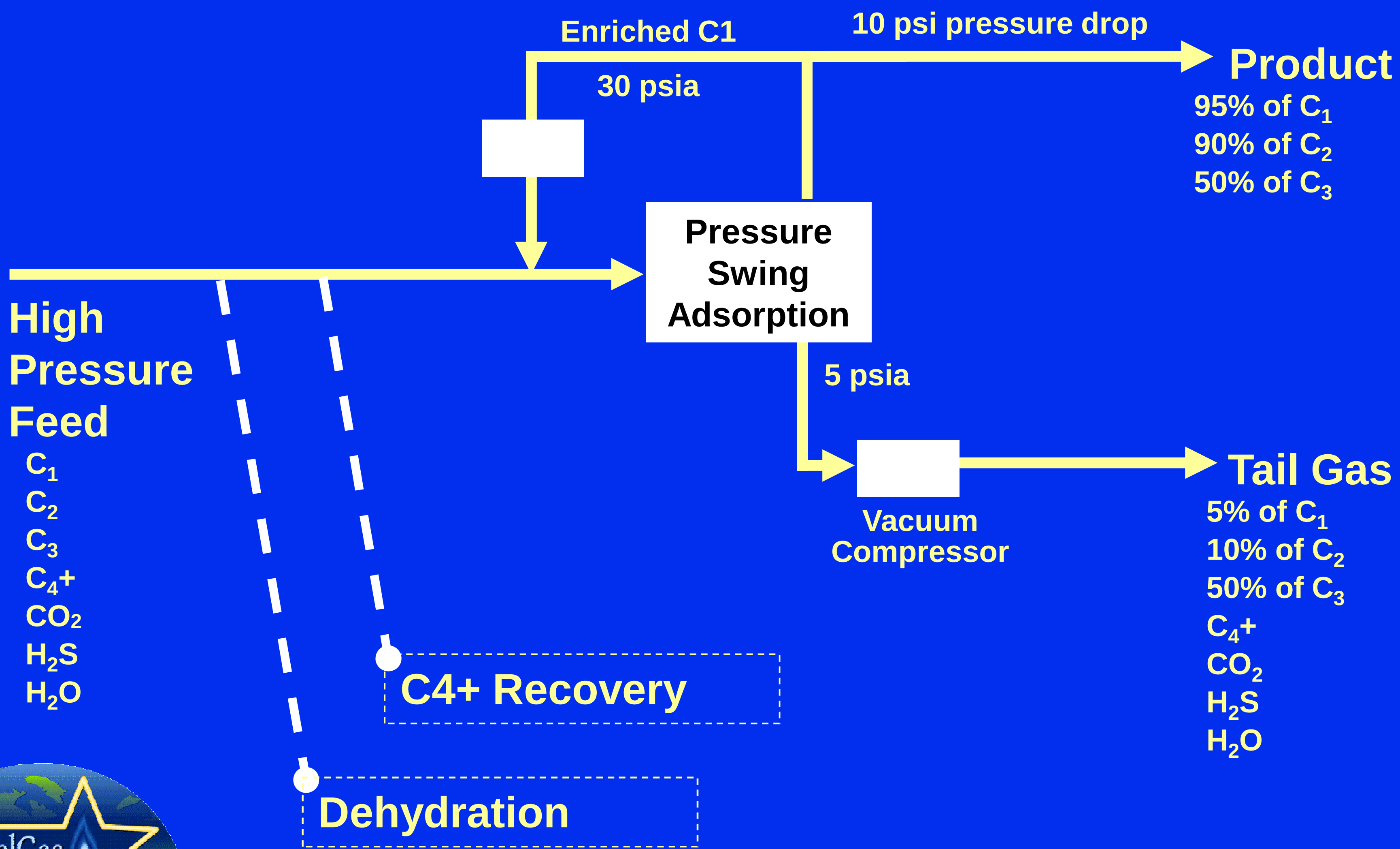
Molecular Gate® Applicability

- Lean gas
  - Gas wells
  - Coal bed methane
- Associated gas
  - Tidelands Oil Production Co.
    - 1 MMcf/d
    - 18% to 40% CO_2
    - Water saturated
  - Design options for C_4+ in tail gas stream
    - Heavy hydrocarbon recovery before Molecular Gate®
    - Recover heavies from tail gas in absorber bed
    - Use as fuel for process equipment

Engelhard Molecular Gate system at a facility in Southern Illinois

www.engelhard.com

Molecular Gate® CO_2 Removal



Industry Experience - Tidelands Molecular Gate® Unit

- First commercial unit started on May 2002
- Process up to 10 MMcf/d
- Separate recycle compressor is required
- No glycol system is required
- Heavy HC removed with CO_2
- Tail gas used for fuel is a key optimization: No process venting
- 18% to 40% CO_2 removed to pipeline specifications (2%)

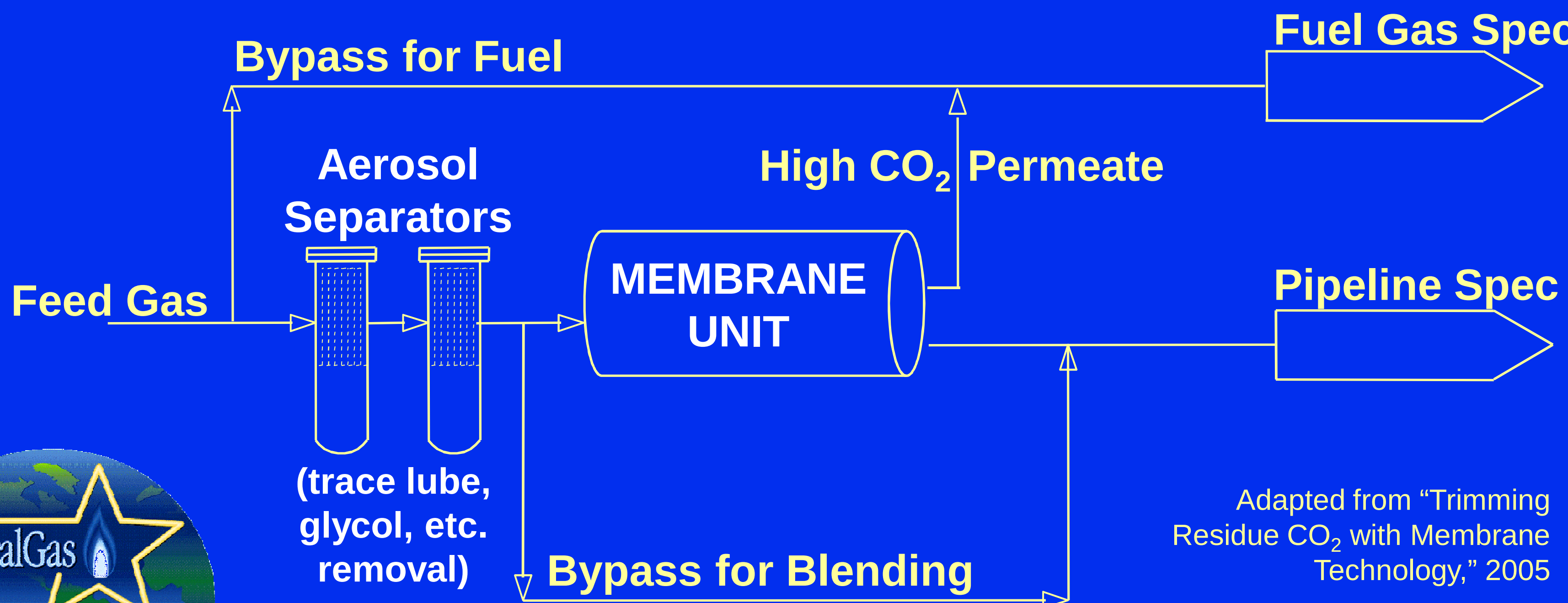
www.engelhard.com/documents/CO2%20Removal-1.pdf

Is Recovery Profitable?

- Molecular Gate® costs are 20% less than amine process
  - **9 to 35 ¢ / Mcf product depending on scale**
- Fixed-bed tail gas vent can be used as supplemental fuel
  - **Eliminates venting from acid gas removal**
- Other Benefits
  - **Allows wells with high acid gas content to produce (alternative is shut-in)**
  - **Can dehydrate and remove acid gas to pipeline specs in one step**
  - **Less operator attention**

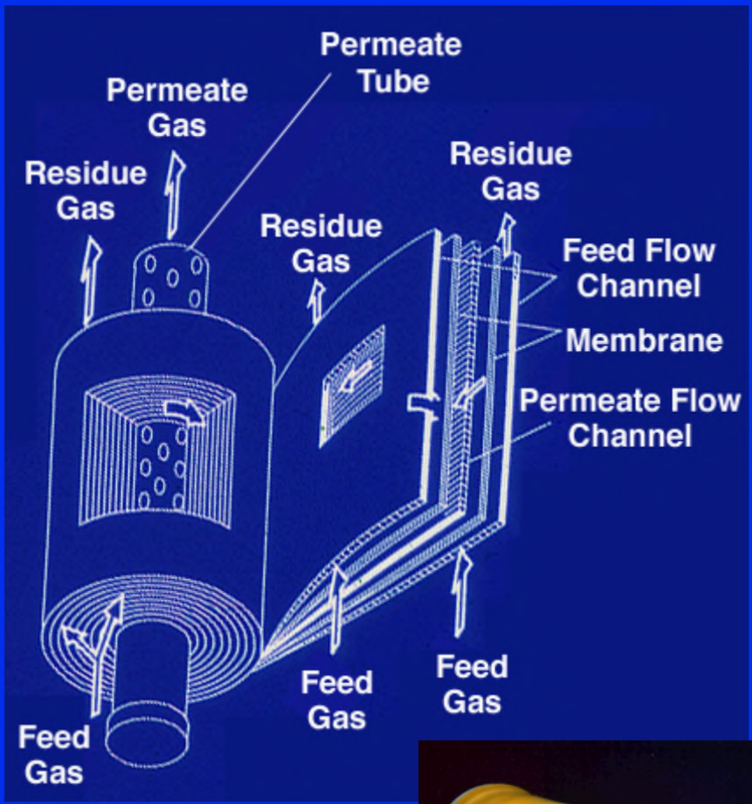
Kvaerner Membrane Process

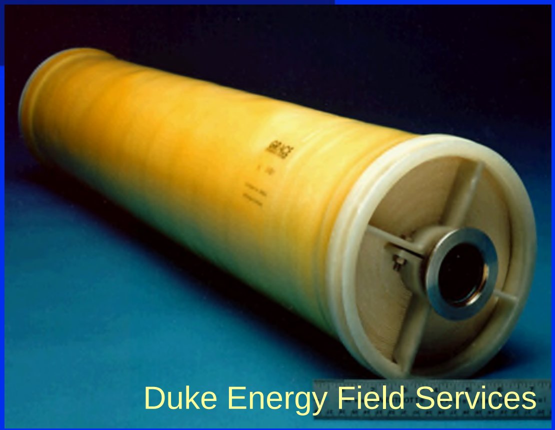
- Membrane separation of CO_2 from feed gas
  - **Cellulose acetate spiral wound membrane**
- High CO_2 permeate (effluent or waste stream) exiting the membrane is vented or blended into fuel gas
- Low CO_2 product exiting the membrane exceeds pipeline spec and is blended with feed gas



Adapted from "Trimming Residue CO_2 with Membrane Technology," 2005

Kvaerner Membrane Technology




Duke Energy Field Services

- CO_2 (and some methane) diffuse axially through the membrane
- High-CO_2 permeate exits from center of tube; enriched product exits from outer annular section
- One application for fuel gas permeate
  - **Methane/CO_2 waste stream is added with fuel gas in a ratio to keep compressor emissions in compliance**
- Design Requirements
  - **Upstream separators remove contaminants which may foul membrane**
  - **Line heater may be necessary**

Industry Experience – Duke Energy

- Kvaerner process installed at Mewborn processing plant in Colorado, 2003
- Problem: Sales gas CO_2 content increasing above the 3% pipeline spec

Duke Energy Field Services

- Evaluated options
  - ◆ **Blend with better-than-spec gas**
    - **Not enough available**
  - ◆ **Use cryogenic NGL recovery to reject CO_2**
    - **Infrastructure/capital costs too high**
  - ◆ **Final choice: membrane or amine unit**

Industry Experience

- Membrane chosen for other advantages; zero emissions is added benefit
  - **65% less capital cost than amine unit**
  - **<10% less operating cost**
  - **<10% less operator man hours**
  - **1/3 footprint of amine unit**
  - **Less process upsets**
  - **Less noise**
  - **Less additional infrastructure construction**
- Typical Process conditions

Flow Into Membrane	Membrane Residue (Product)	Membrane Permeate
22.3 MMcf/d	21	1.3
70 to 110 °F	70 to 110	70 to 110
800 to 865 psia	835	55
3% CO_2	2%	16%
84% C1	89%	77%
13% C2+	9%	7%
~0% H_2O	~0%	~0%
~0% H_2S	~0%	~0%

Is Recovery Profitable?

- Costs
  - **Conventional DEA AGR would cost $4.5 to $5 million capital, $0.5 million O&M**
  - **Kvaerner Membrane process cost $1.5 to $1.7 million capital, $0.02 to $0.05 million O&M**
- Optimization of permeate stream
  - **Permeate mixed with fuel gas, $5/Mcf fuel credit**
  - **Only installed enough membranes to take feed from >3% to >2% CO_2, and have an economic supplemental fuel supply for compressors**
- In operation for 1 year
- Offshore Middle East using NATCO membrane process on gas with 90% CO_2, achieving pipeline spec quality

Comparison of AGR Alternatives

	Amine (or Selexol™) Process	Morphysorb® Process	Molecular Gate® CO_2	Kvaerner Membrane
Absorbent or Adsorbent	Water & Amine (Selexol™)	Morpholine Derivatives	Titanium Silicate	Cellulose Acetate
Methane Savings	100%	66 to 75%	0%	0% or higher
Regeneration	Reduce Pressure & Heat	Reduce Pressure	Reduce Pressure to Vacuum	Replace Membrane ~5 years
Primary Operating Costs	Amine (Selexol™) & Steam	Electricity	Electricity	Nil
Capital Cost	100%	75%	<100%	35%
Operating Cost	100%	60% to 70%	80%	<10%

Discussion Questions

- Have you studied any of these new technologies?
- How can our presentation be improved to help you find new opportunities to reduce methane emissions from AGR units?
- What are the barriers (technological, economic, lack of information, regulatory, focus, manpower, etc.) that are preventing you from implementing either of these technologies?