Intensification for Processing Associated and Stranded Gas

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Talk Outline

- Associated and Stranded Gas
- Options for Stranded Gas
- Gas Processing Plant
- Process Intensification for Stranded Gas

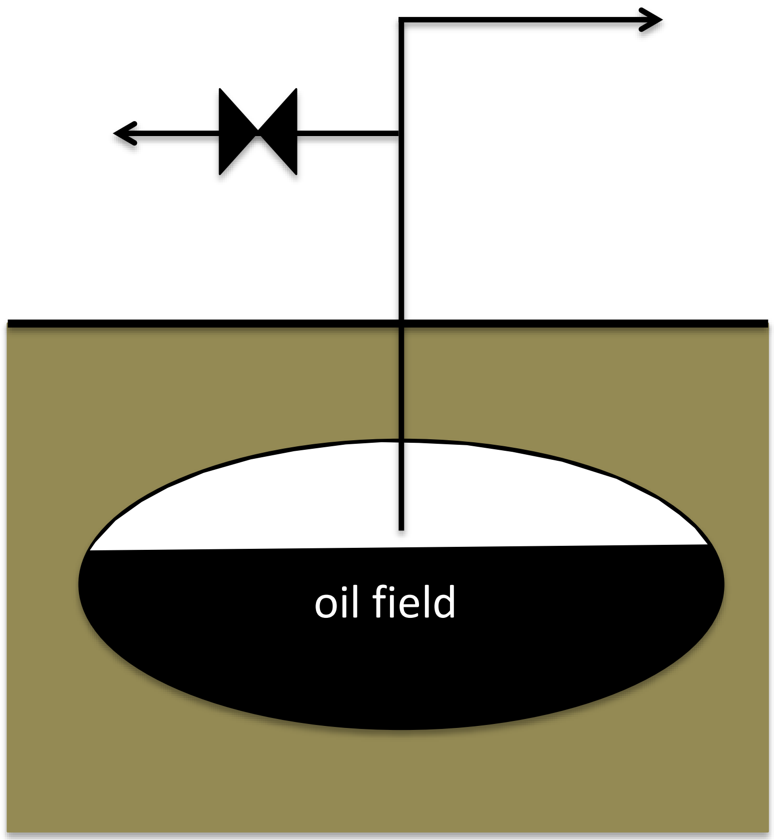
FPSO – Shell Prelude

Gas

- Abundant Reserve - (161 x 10^{12} m^3)
- Low Carbon fuel (compared to coal/oil)
- Expensive to transport
- Typically contains:
  - $C_1 – C_6$ hydrocarbons
  - acid gases (H_2S and CO_2)
  - water
  - nitrogen and trace impurities

- 40 - 60% of the world's natural gas is stranded gas.

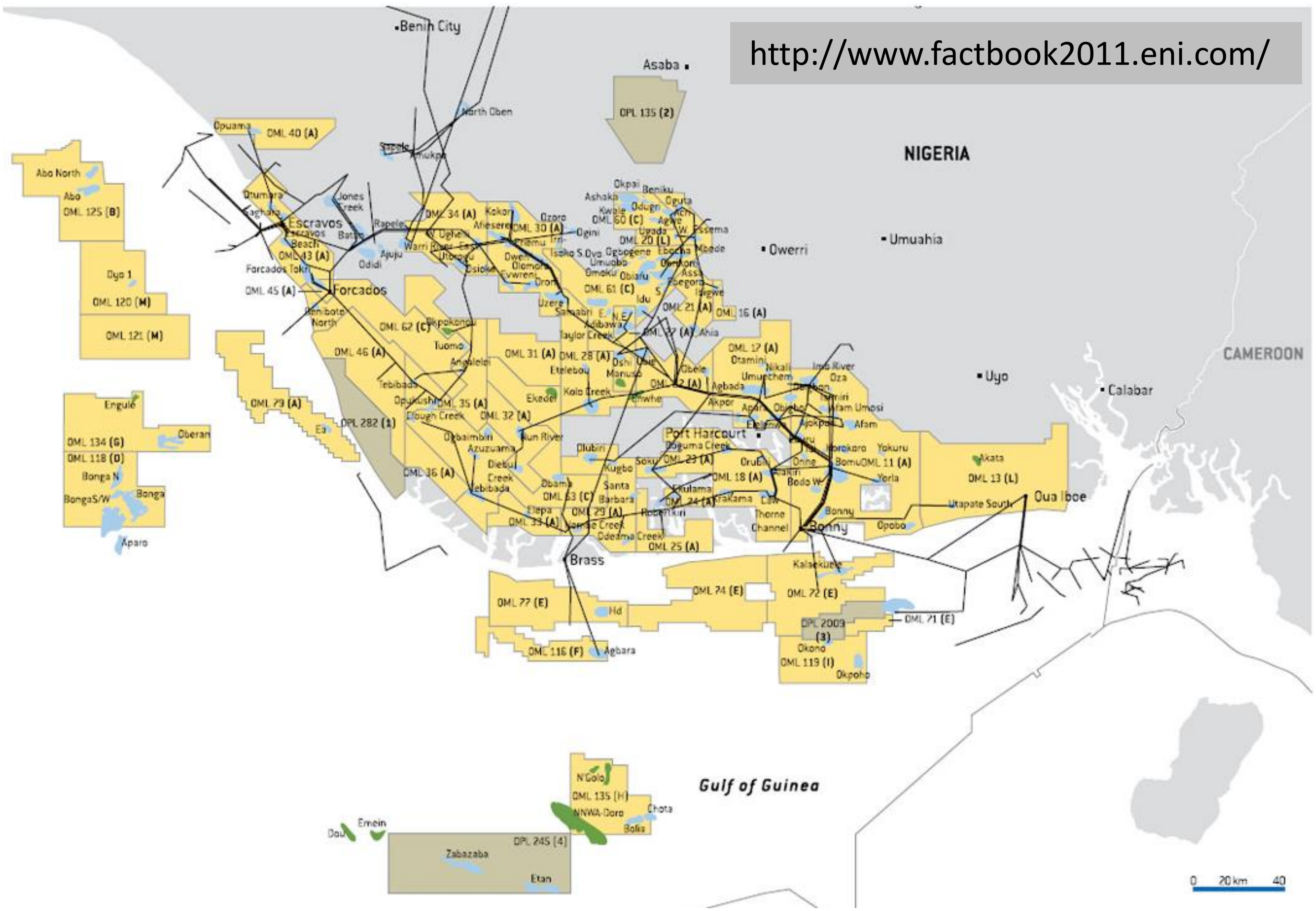
Associated Gas



Associated Gas

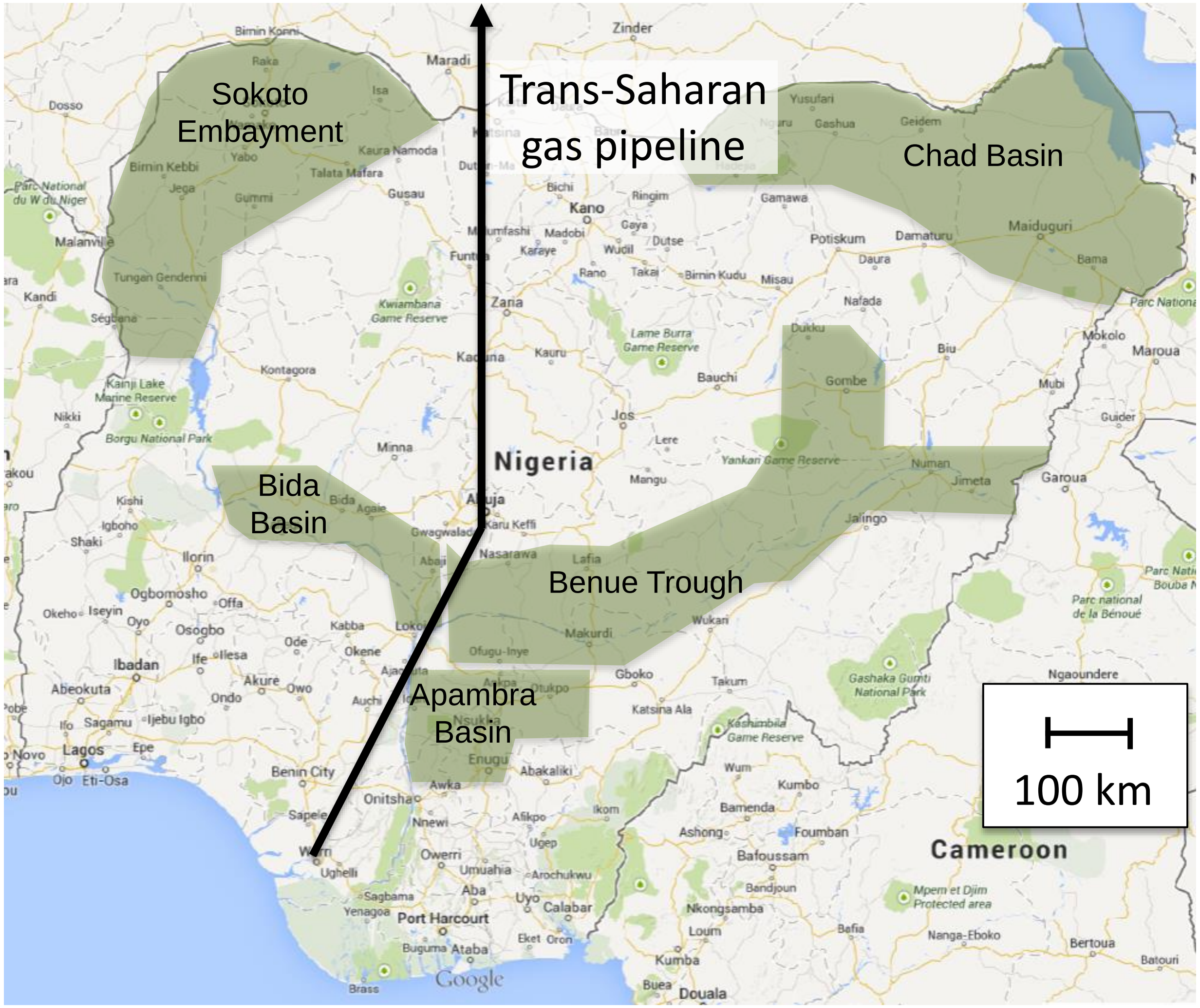
- In 2009 150 billion m^3 of associated gas were flared[1].
- Equivalent to 25% of United States and 30% of EU gas consumption.
- Uses could include
  - Power generation
  - Enhanced Oil Recovery
  - Petrochemicals

Stranded Gas - I

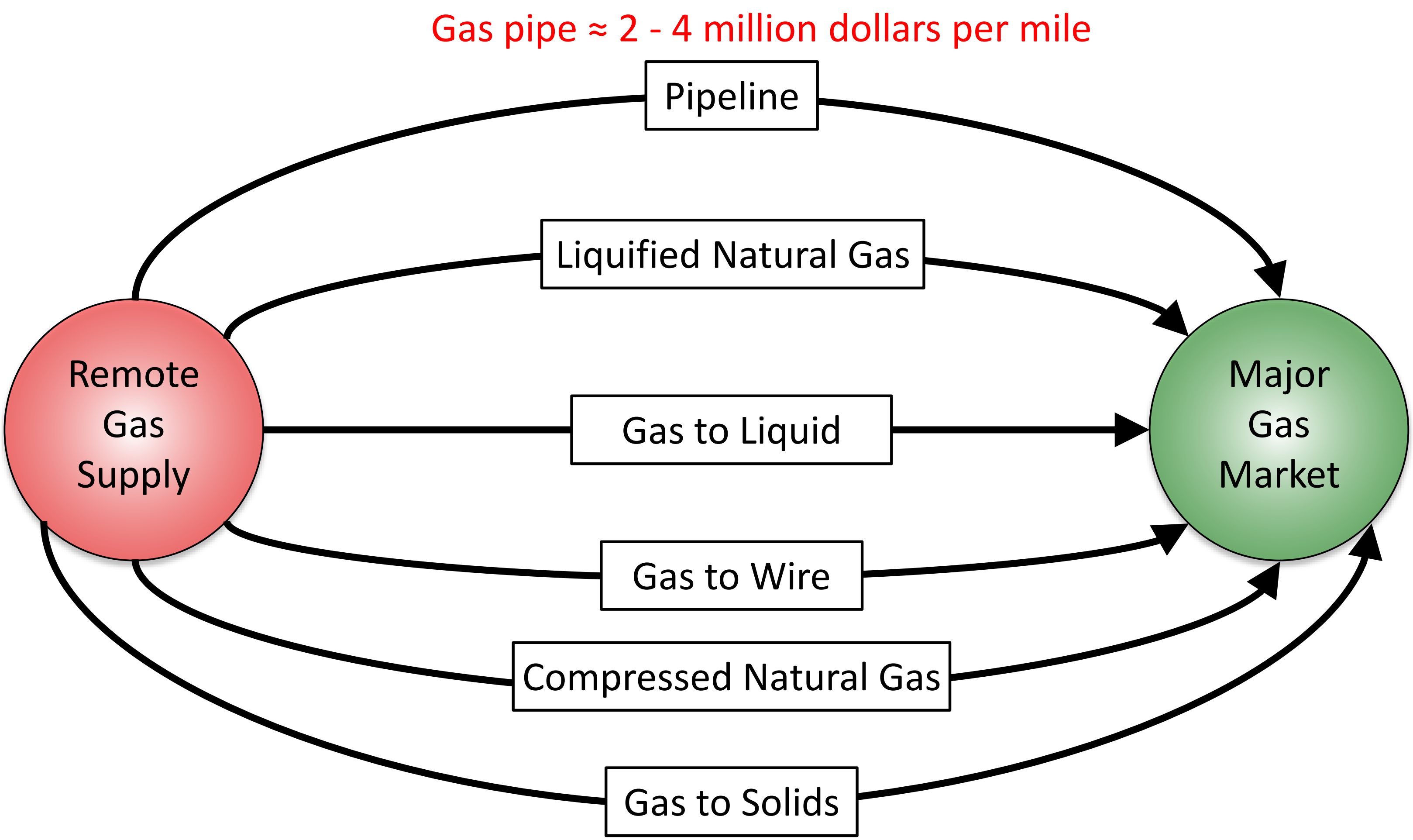


Gas that has been produced and processed but is geographically isolated from a market

Stranded Gas - II



Options for Stranded Gas

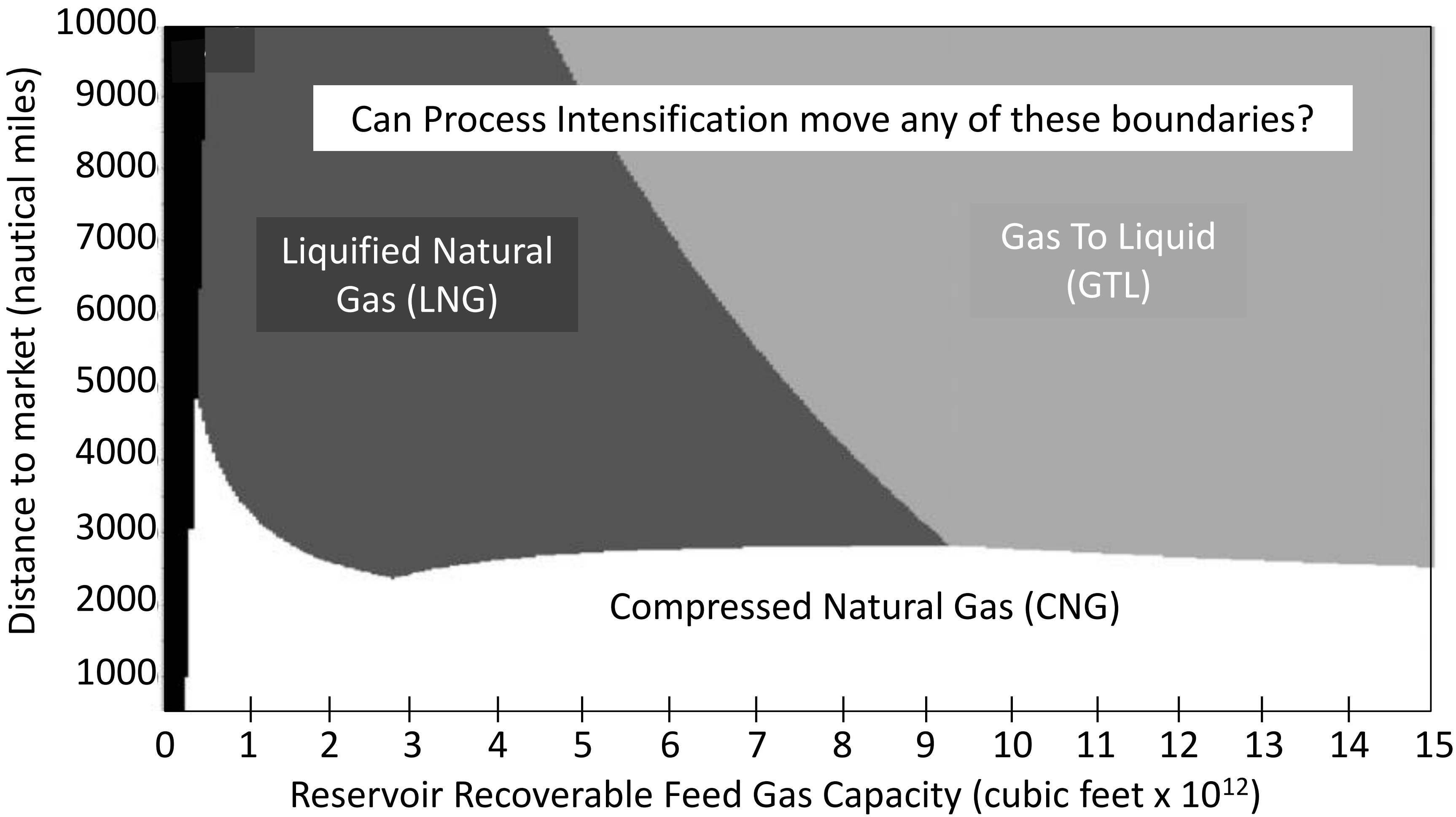


Adapted from Wood, Ref 2.

Options for Stranded Gas

- Khalilpour[3] considered three options:
  - Liquified natural gas (LNG)
  - Compressed natural gas (CNG)
  - Gas to liquids (GTL)
- Historical data for capital and operating costs were used.
- Assumption was made that pipeline specification gas was available at market price.
- Oil price and gas price treated as ranged, random variables.

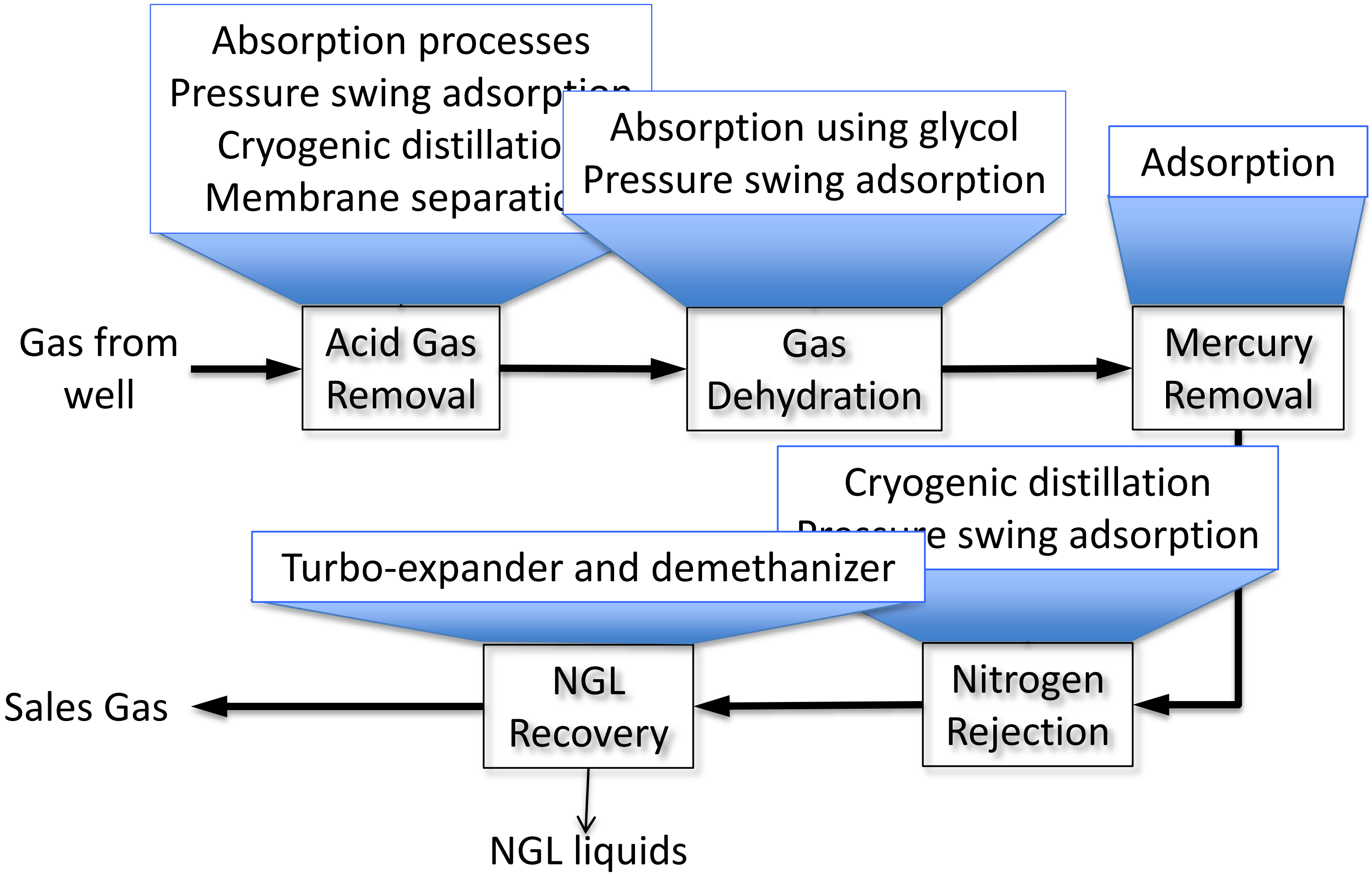
Options for Stranded Gas



1 nautical mile = 1.85 km

1×10^{12} ft^3 = 28.3×10^9 m^3

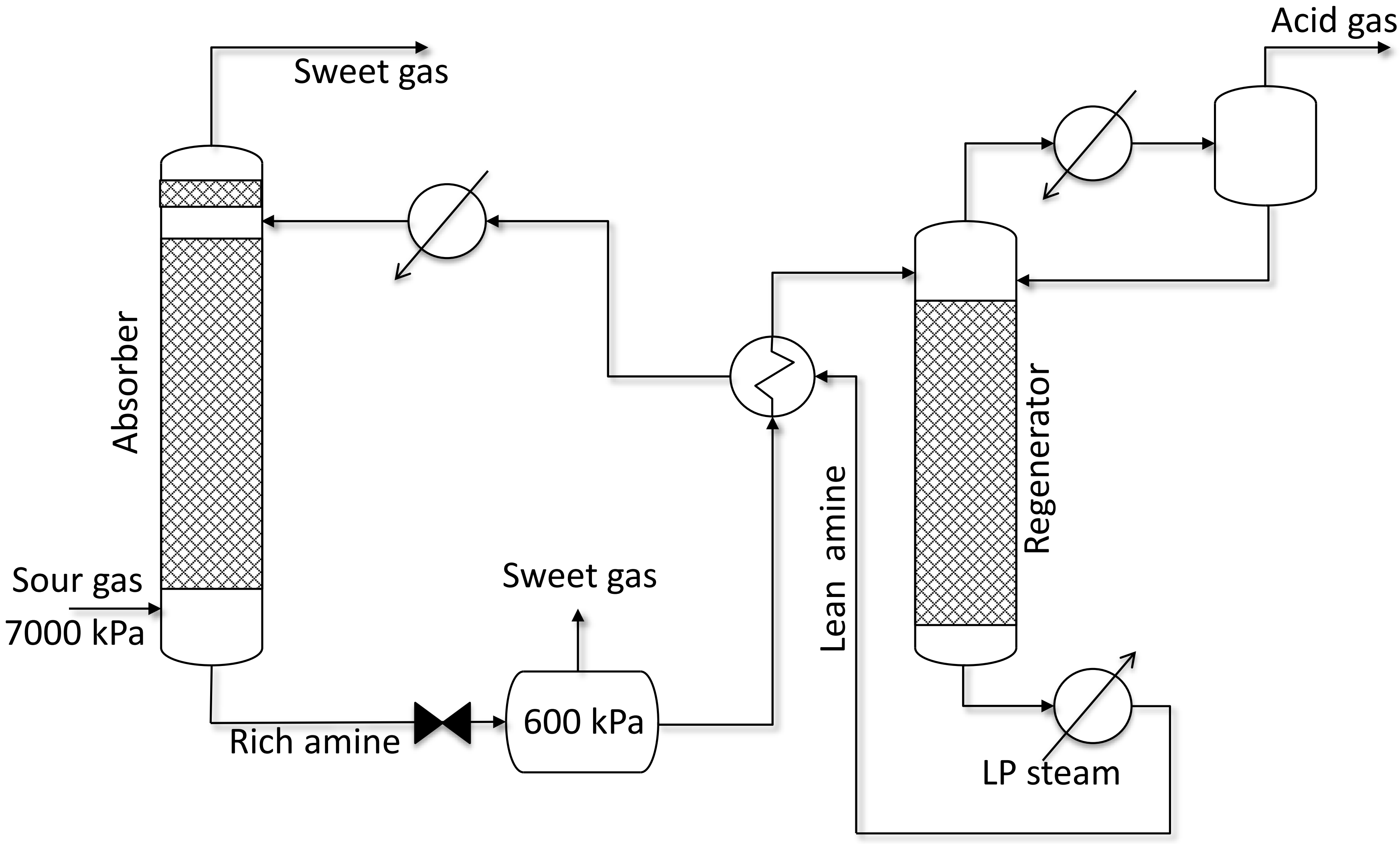
Gas Processing



Gas Processing

- All the options for stranded gas involve some processing
  - Pipeline: All
  - LNG: All
  - CNG: All
  - Gas to wire: acid gas removal, mercury removal
  - Gas to liquid: acid gas removal, mercury removal
  - Gas to solid: acid gas removal, mercury removal, NGL recovery.

Acid Gas Removal Using Amines



Intensified Adsorber

- Gas field producing 1.4 billion cubic meters per year (at STP).
- Reduce the sulfur content to pipeline spec of 10 ppm(molar).
- Rich amine loading of 0.4 mol_{CO2} per mol amine. 30 mass% amine solution.
- The ΔP in the column and rotating packed bed are the same.
- ε = 97%, a = 250 m^2 m^{-3}
- Mass transfer coefficient ($K_G a$) in the packed column is 0.02 s^{-1}
- Mass transfer coefficient ($K_G a$) in the RPB from the data of Jassim[4]

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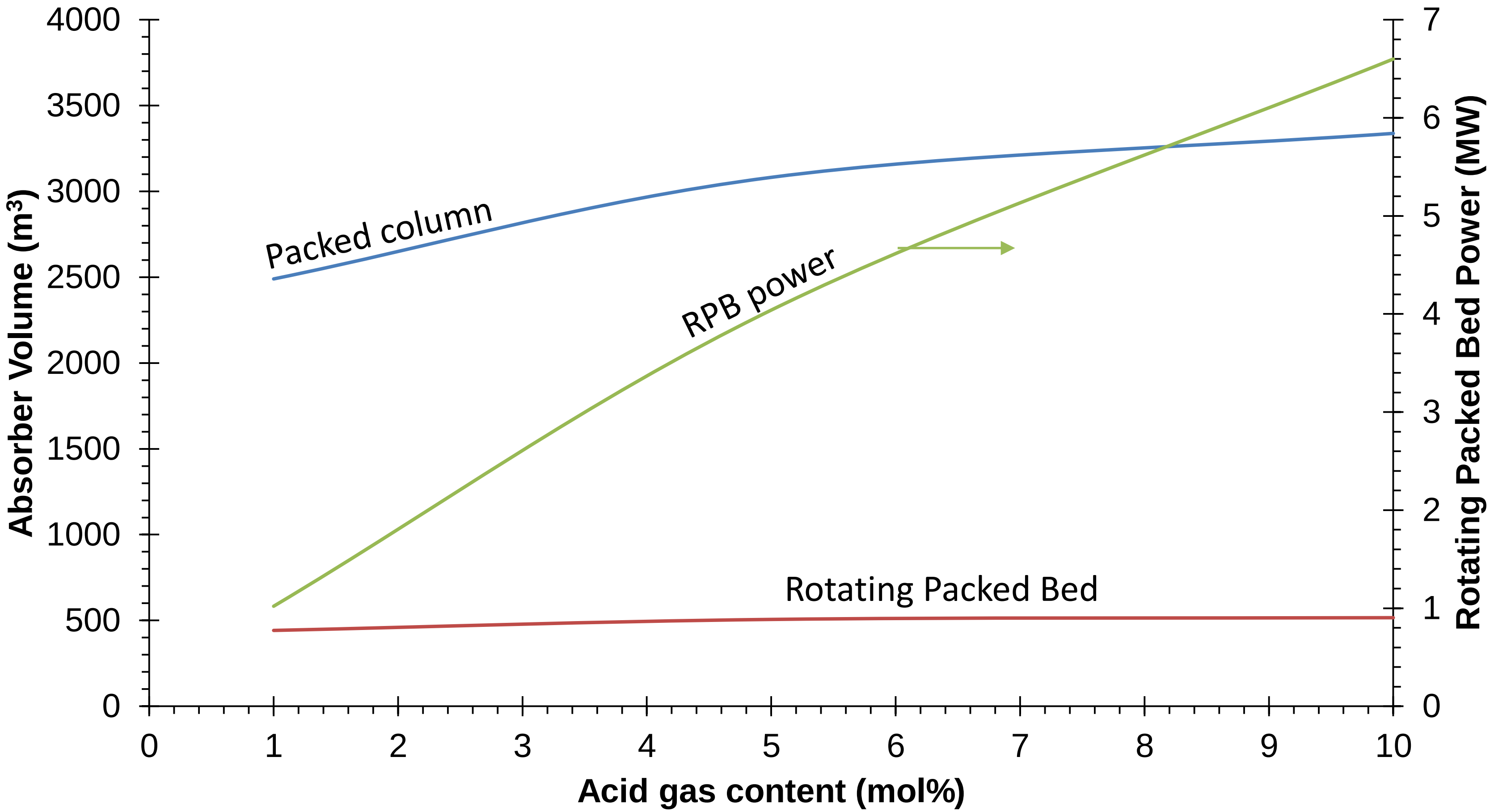
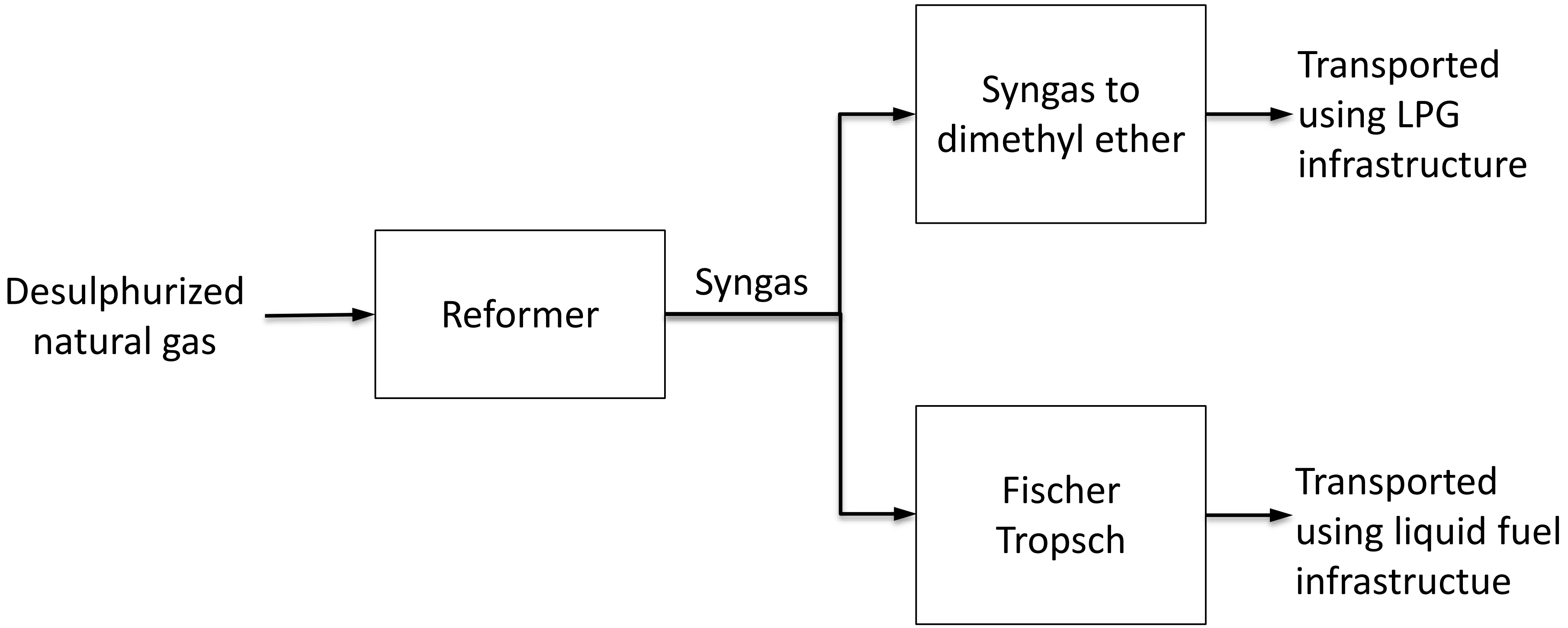
Intensified Adsorber

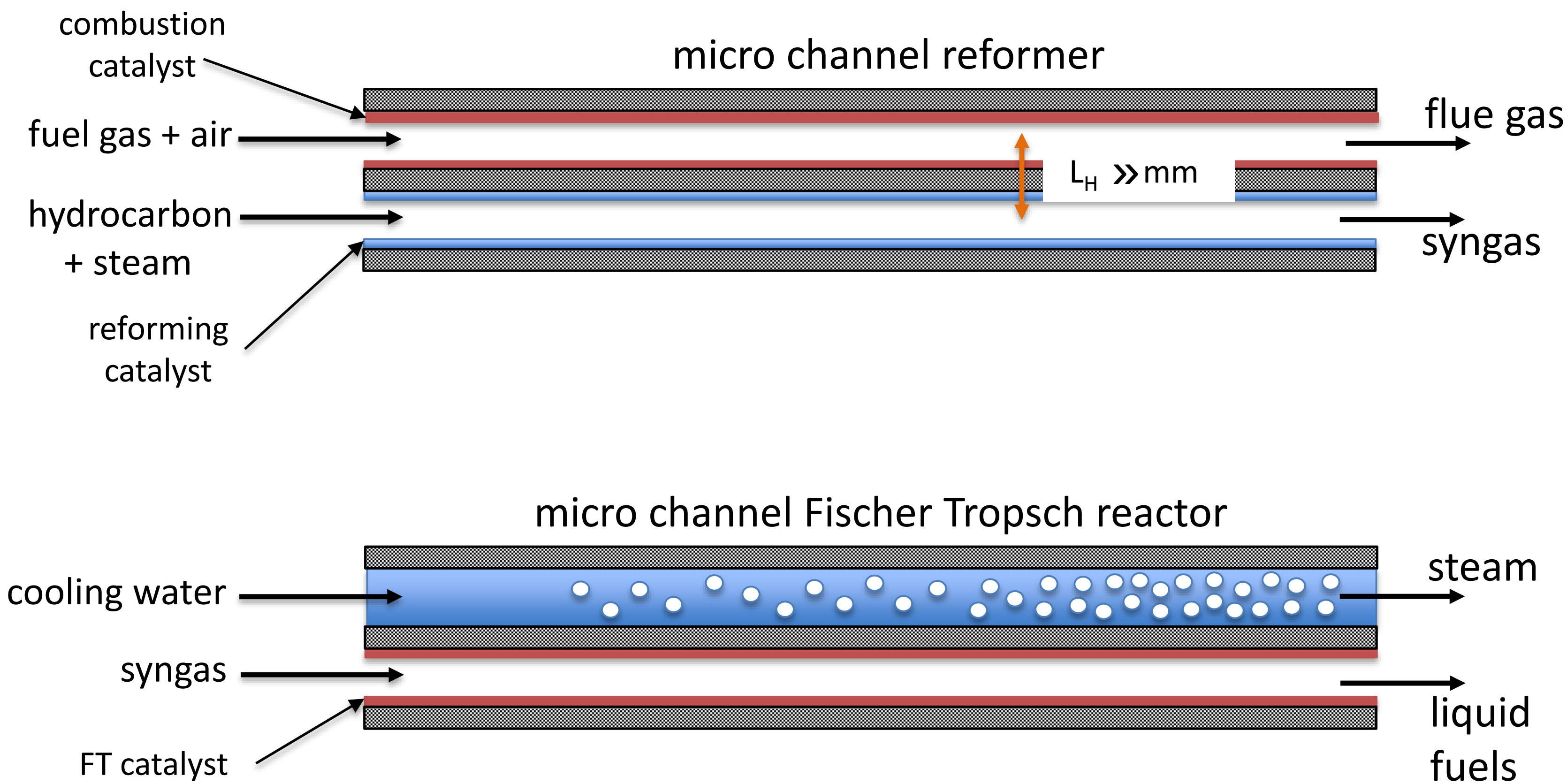


- Capital cost savings have to offset the added operating cost of the RPB.
- Use higher concentration amine solutions in the RPB

Gas to Liquid (GTL)



Intensified GTL



- Intensification of the heat transfer process leads to compact reactors
- Technology commercialized by Velocys and CompactGTL

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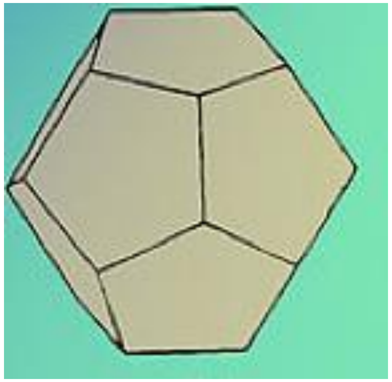
Gas to Solids

	Liquified Natural Gas	Compressed Natural Gas	Gas Hydrates
Temperature	-162˚C	ambient	-10˚C
Pressure	1 bar	206 bar	1 bar
Gas content of 1 m^3 at STP	600 m^3	200m^3	160m^3



Gas Hydrate

Water molecules hydrogen bonded in a cage around a gas molecule

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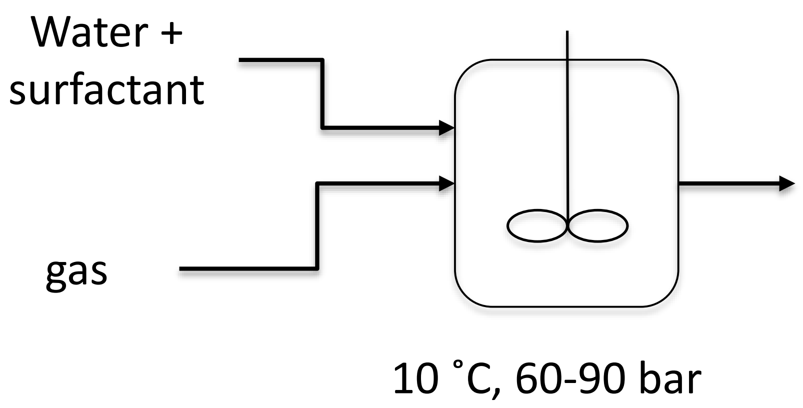
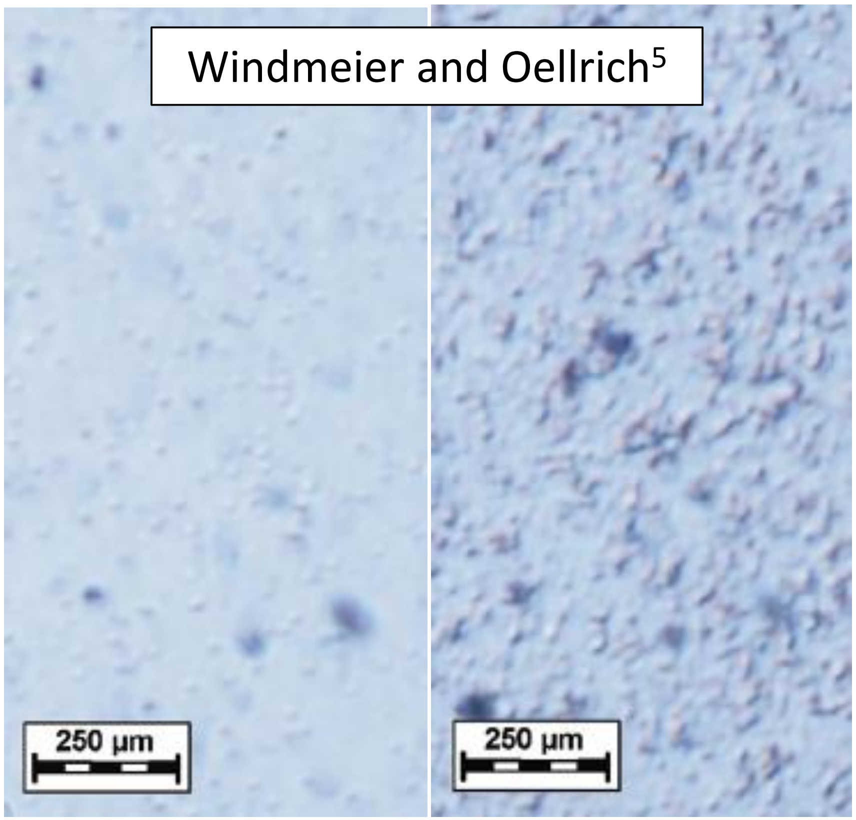
Gas to Solids





- Process is thermodynamically driven by pressure.
- Rate of hydrate formation is thought to be mass transfer controlled and could be intensified.

Conclusions

- Utilizing stranded gas is a complex problem with many technical solutions
- Feasible options for stranded/associated gas need to be evaluated and niches for the application of Process Intensification identified.
- Process flow rates are large even for small fields.
- It is an area with potential for process intensification.

Thank you for listening

Any Questions?

References

1. http://www.worldbank.org/en/topic/sustainabledevelopment

2. Wood D, Mokhatab S, 2008, "Gas monetiziation technologies remain tantalizingly on the brink", World Oil, 229, 15

3. Khalilpour R, Karimi I A, 2012, "Evaluation of utilization alternatives for stranded natural gas", Energy, 40, 317-328

4. Jassim M, Rochelle G, Eimer D, Ramshaw C, 2007, "Carbon Dioxide Adsorption and Desorption in Aqueous Monoethanolamine Solutions in a Rotating Packed Bed", Ind.Eng.Chem.Res., 46, 2823-2833.

5. Windmeier C, Oellrich L R, 2014, "Visual observation of methane hydrate formation and dissociation process", Chemical Engineering Science, 109, 75-81.

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