

CO₂ Removal from Natural Gas

GCEP Energy Workshop
Carbon Capture & Separation
Stanford University

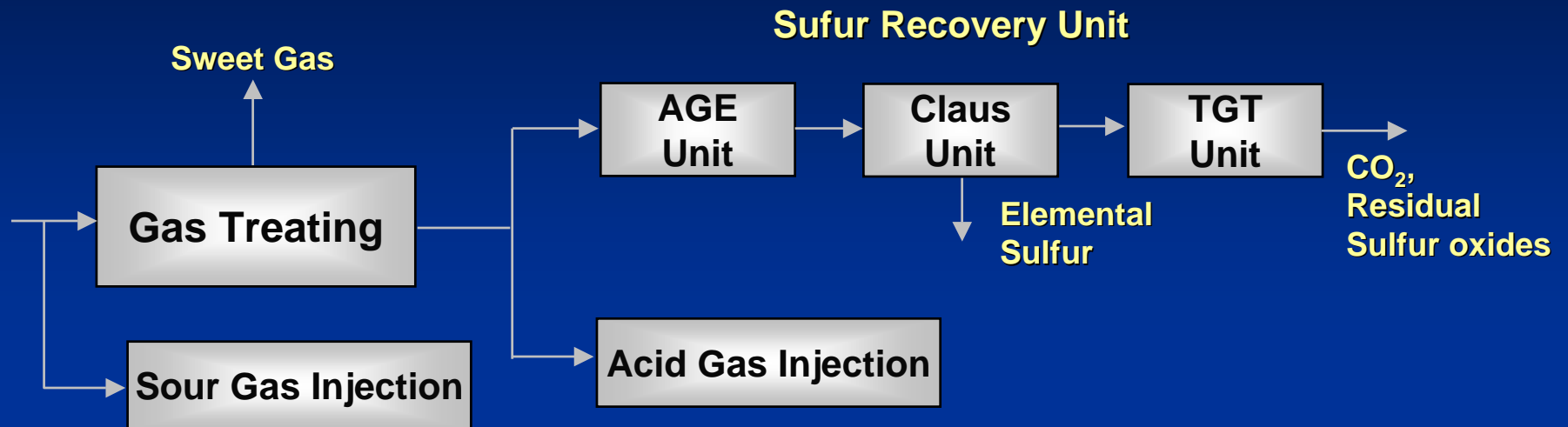
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27 April 2004

Topics

- **ExxonMobil Gas Treating Overview**
- **Membrane Separation**
- **Cryogenic CO2 Separation**
- **Gas Injection**
- **Possible Research Directions**

Gas Treating and Injection



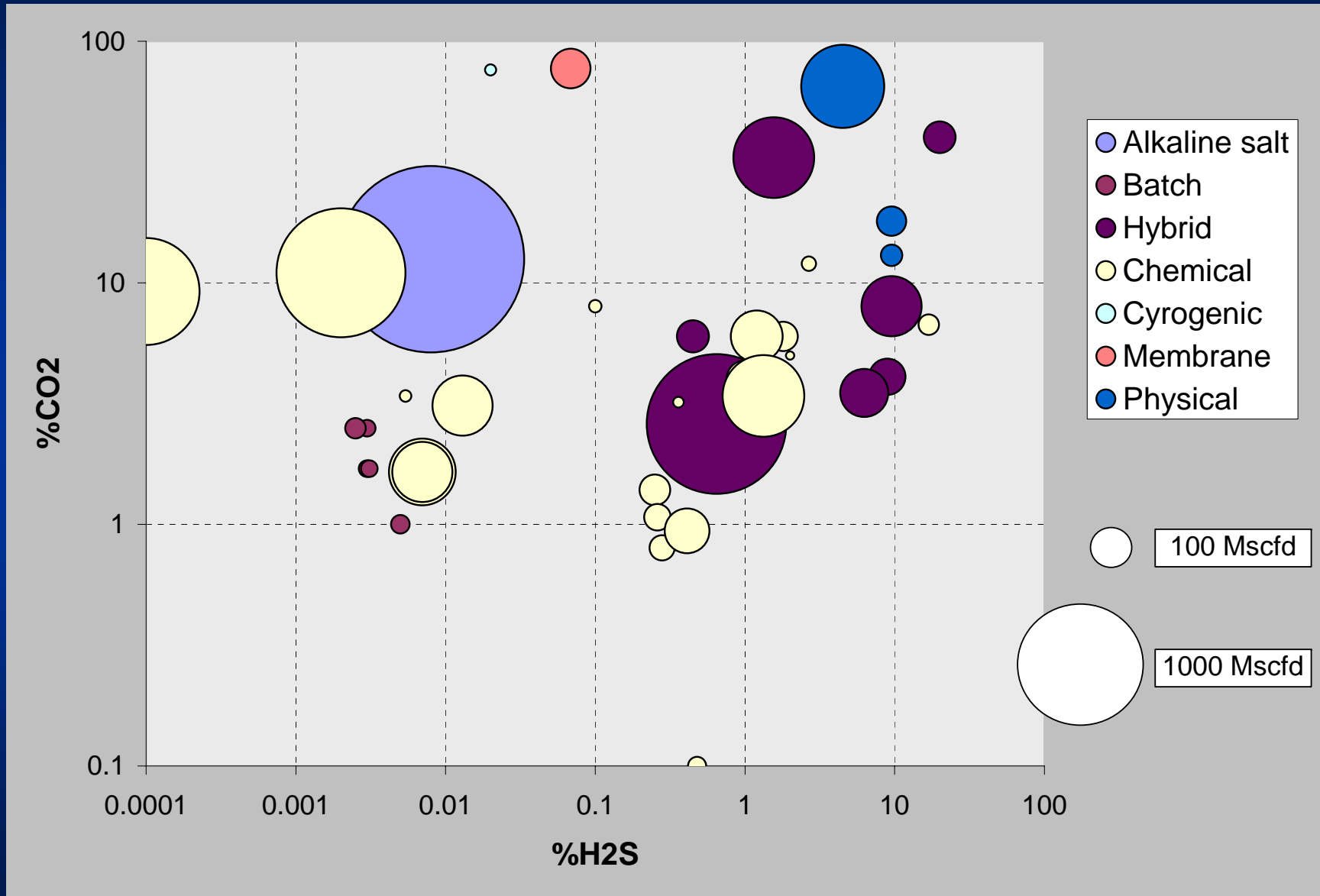
Gas Treating

- Solvents
 - Chemical
 - Physical
 - Hybrid
- Membranes
- Cryogenic
- Alkaline salts
- Batch

Sour/Acid Gas Injection

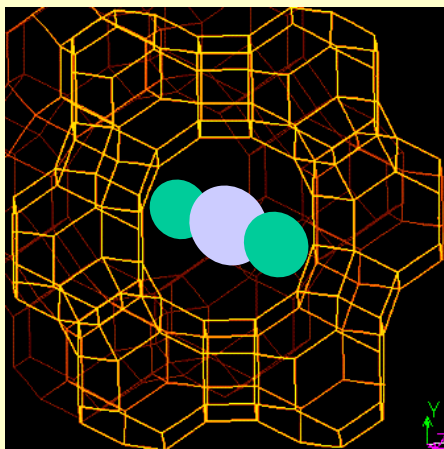
- Alternative to sulfur disposal
- Captures other environmental benefits
- Can reduce life-cycle costs
- Potential for improved recovery

Gas Treating



Inorganic Membrane Materials For CO₂/CH₄ Separation

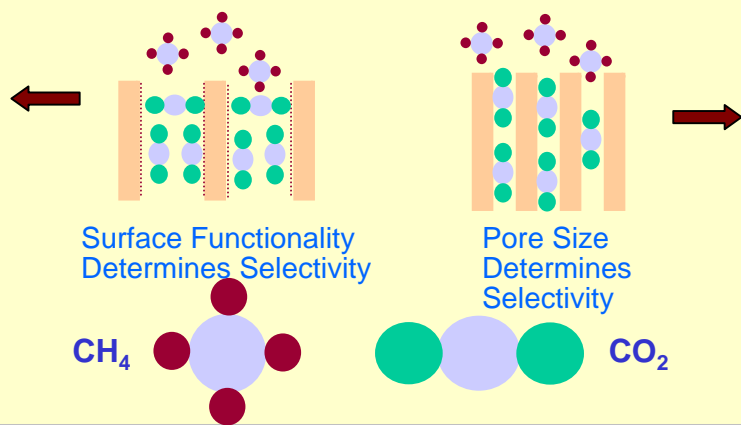
Large Pore Zeolite



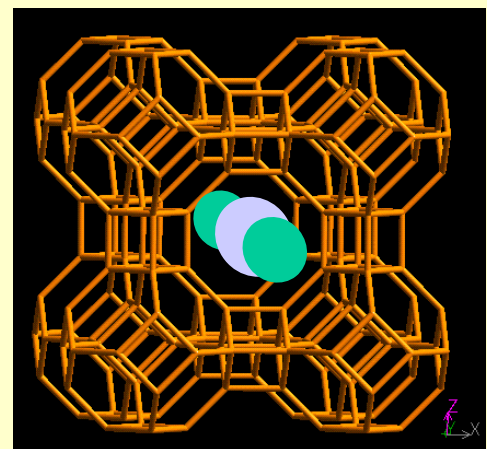
Separation Mechanisms

Competitive Sorption

Molecular Sieving



Small Pore Zeolite



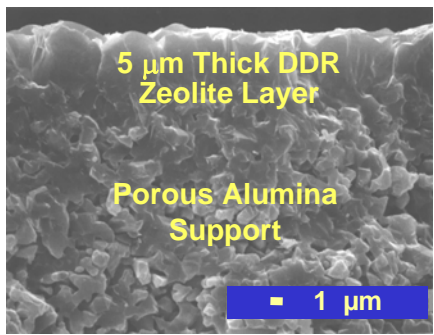
Zeolites ($M_x Si_{1-x} Al_x O_2$)

Silica (SiO_2)

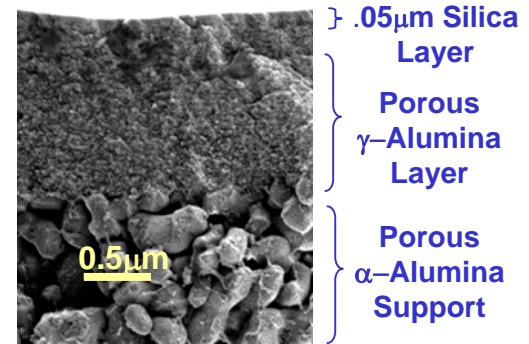
Can operate via either mechanism
Membrane fabrication challenging

Both separation mechanisms in play
Pores have hydroxyl groups that sorb water

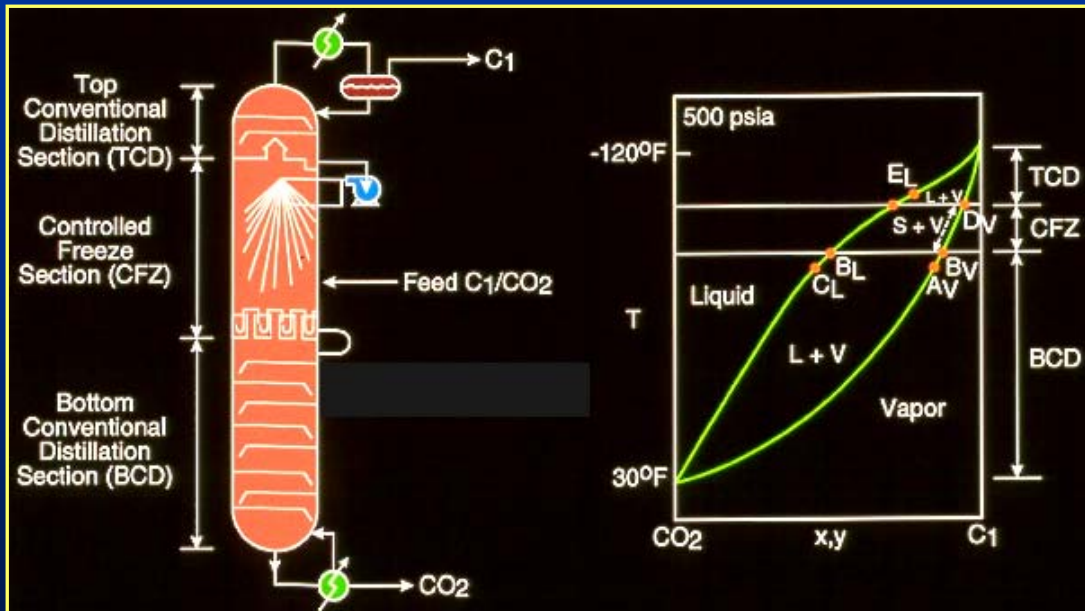
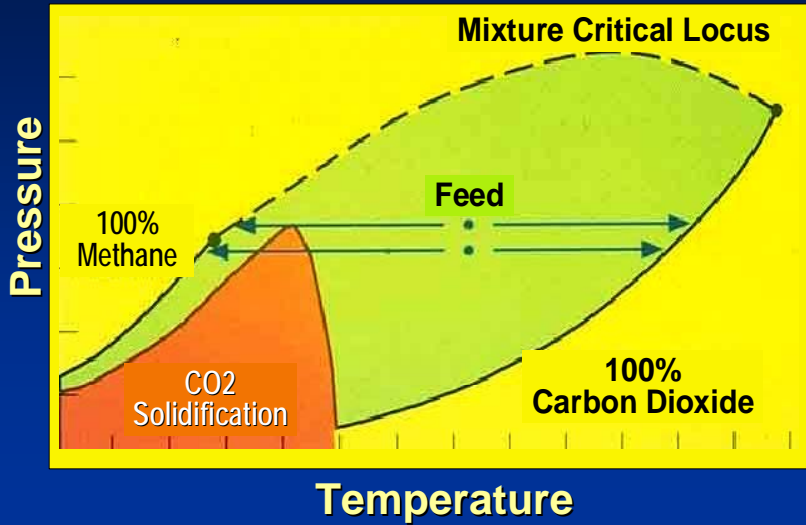
- Very high CO₂/CH₄ selectivity (>200)
- Good fouling resistance



- Very High CO₂/CH₄ selectivity (>100)
- Water stability is an issue

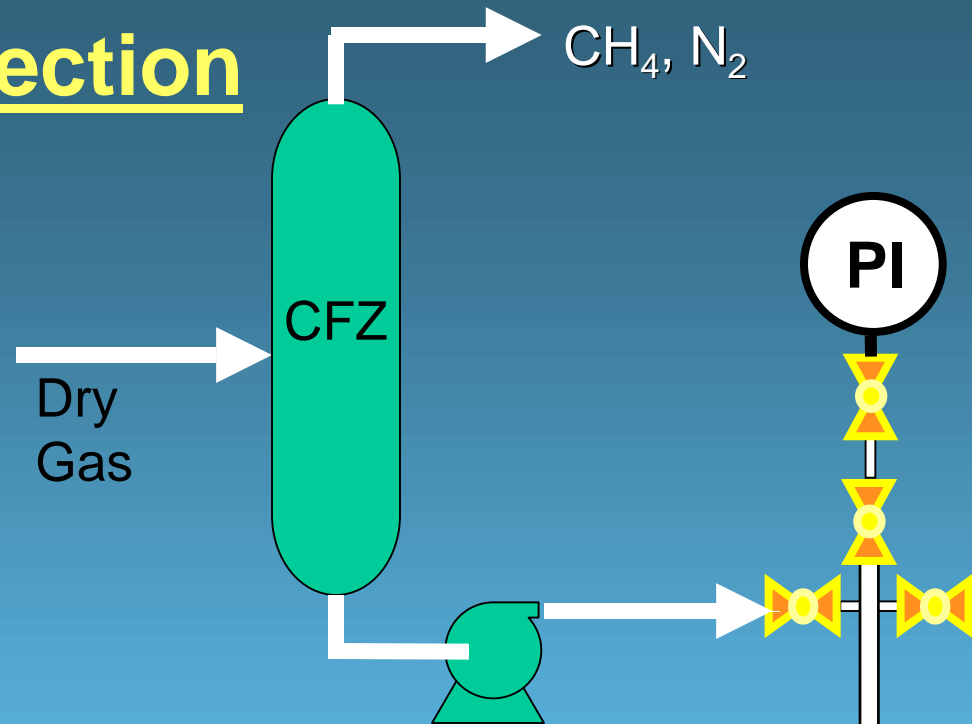


Cryogenic CO₂ Separation



Integration with Injection

CFZ is easily integrated with acid gas injection



- **H₂S/Sulfur**

- Eliminates Claus/TGT units, sulfur blocks
- + Saturated sulfur markets
- + Slow development of alternative uses

- **CO₂**

- Some producers may have CO₂ incentives
- Enhanced oil recovery possible

H₂S, CO₂

Sweetening Process Screening

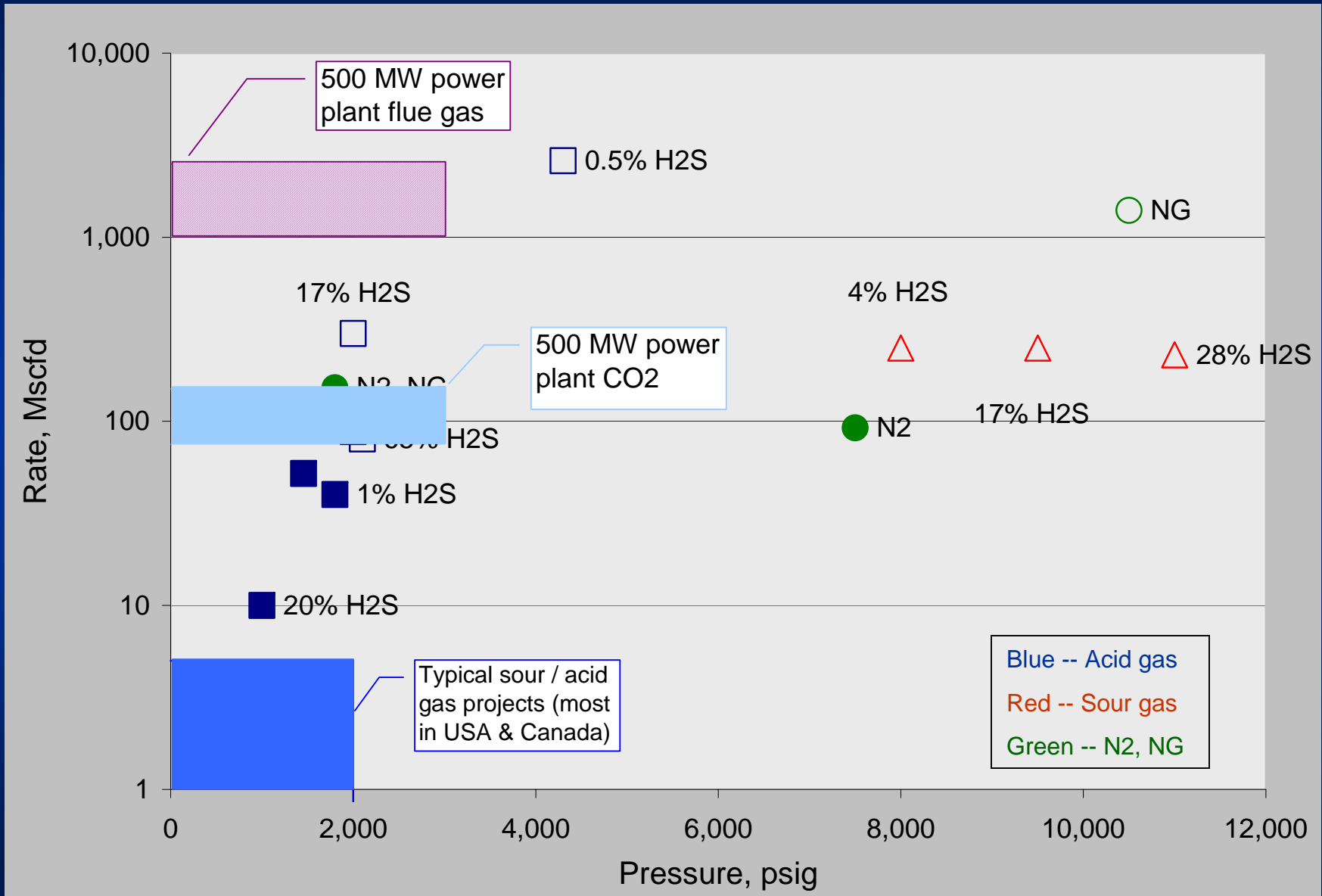
100 Mscfd, 40% acid gas & 950 psig plant inlet

	<u>Chemical</u>	<u>Physical¹</u>	<u>CFZ¹</u>
Capital Investment	1.4	1.3	1.0
Annual Operating Cost	1.4	1.19	1.0
Plant Horsepower	1.5	1.41	1.0
Gas sales	0.91	0.93	1.0

1 -- from study by independent consultant

Acid & Sour Gas Injection

Existing, Planned, or Evaluated



Possible Research Directions for CO₂ Capture

GCEP goal: Identify and conduct fundamental, pre-commercial research to overcome barriers that will allow technology options to become commercially viable

Challenge: Make electric power production with low specific CO₂ emissions cost competitive assuming no non-market incentives

- **Fundamental not incremental**
- **Economically competitive not just improved economically**
- **Leveraged and integrated with best efforts to date that have identified and evaluated CO₂ capture technologies**
- **Applicable to multiple future scenarios**