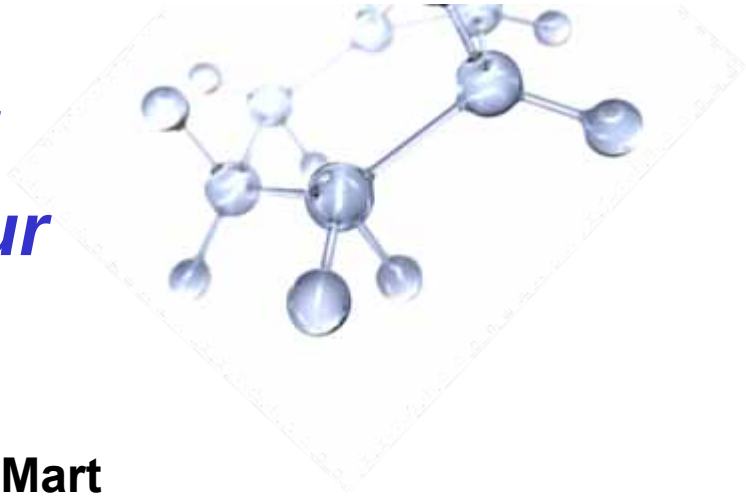
ExxonMobil
Upstream Research

Controlled Freeze Zone™ Technology – An Integrated Solution for Processing Sour Natural Gas



Charles J. (Chuck) Mart
Research Manager, Gas Technology
ExxonMobil Upstream Research Company

GCEP
Global Climate & Energy Project
STANFORD UNIVERSITY

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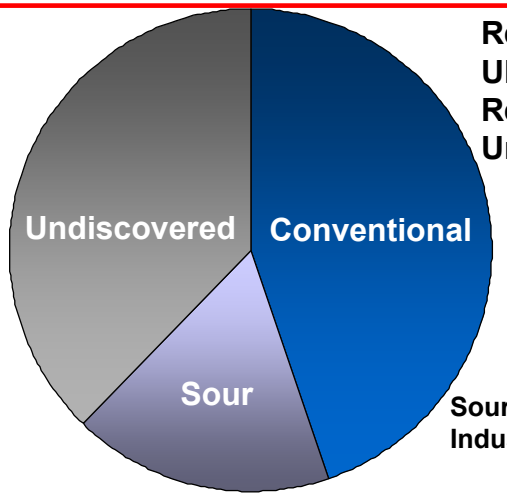
Outlook for Natural Gas

- Natural gas expected to be the fastest growing fuel source for the next 20 years
- Demand growth expected in power generation sector because of lower emissions and greater efficiency with natural gas fired units
- Domestic and imported supplies will be needed to meet regional gas demands via pipeline and LNG deliveries

Challenges with Sour Natural Gas Resources

- **Increasingly sour global gas resources**
  - As much as 1/3 of global conventional resources have significant amounts of CO_2 and H_2S
  - Fields with CO_2 contents greater than 30% and H_2S content greater than 10% are encountered more frequently
- **Management of contaminants**
  - Increased focus on CO_2 removal and disposition
  - Alternatives to sulfur production
  - Geosequestration of CO_2
- **Challenging economics for developing sour gas reserves**
  - Smaller amounts of valuable hydrocarbon
  - Remote gas developments

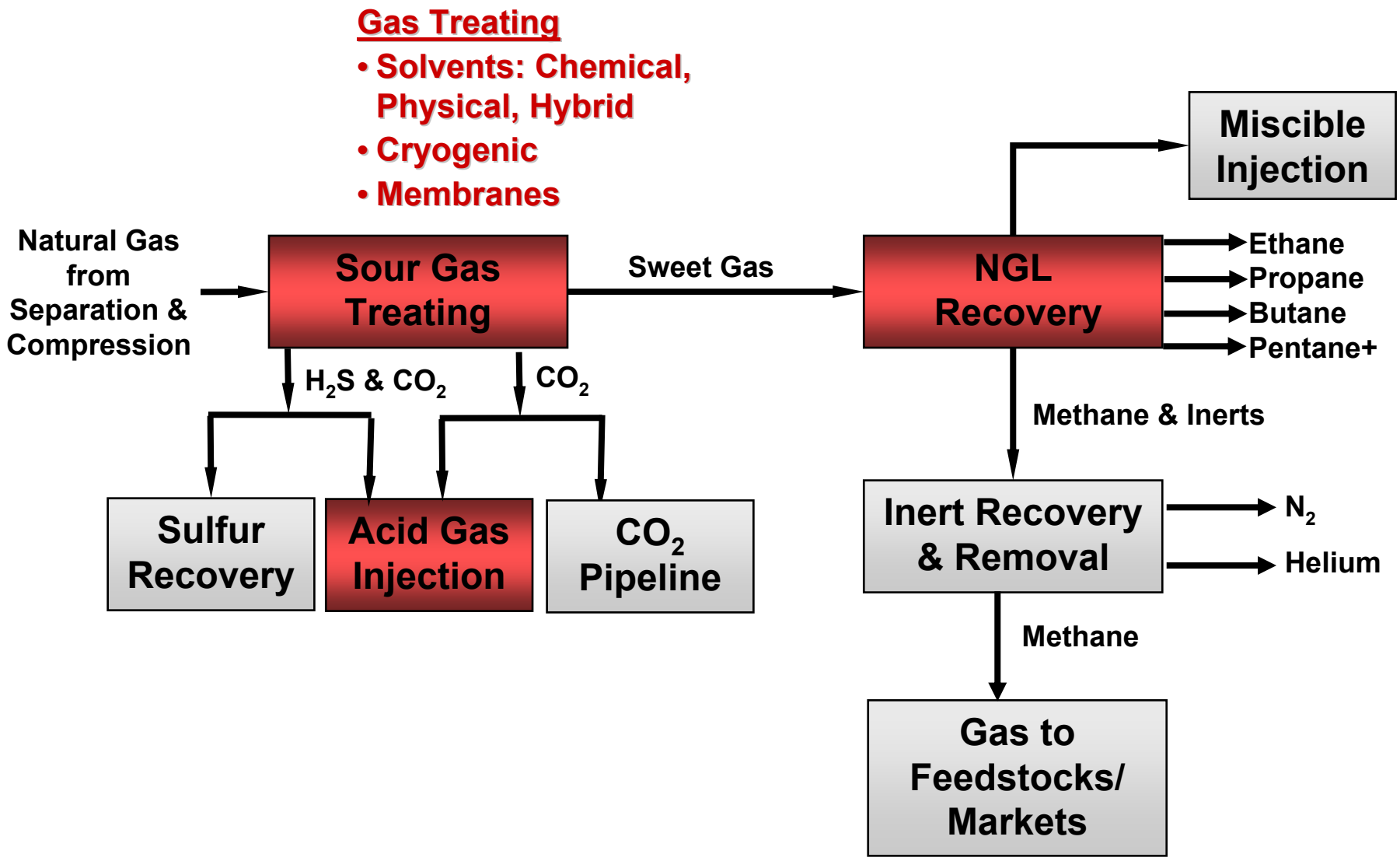
Global Gas Resource Distribution



Remaining Ultimate Recoverable - Undeveloped

Source: USGS; Industry database

Simplified Flow Schematic – Gas Processing



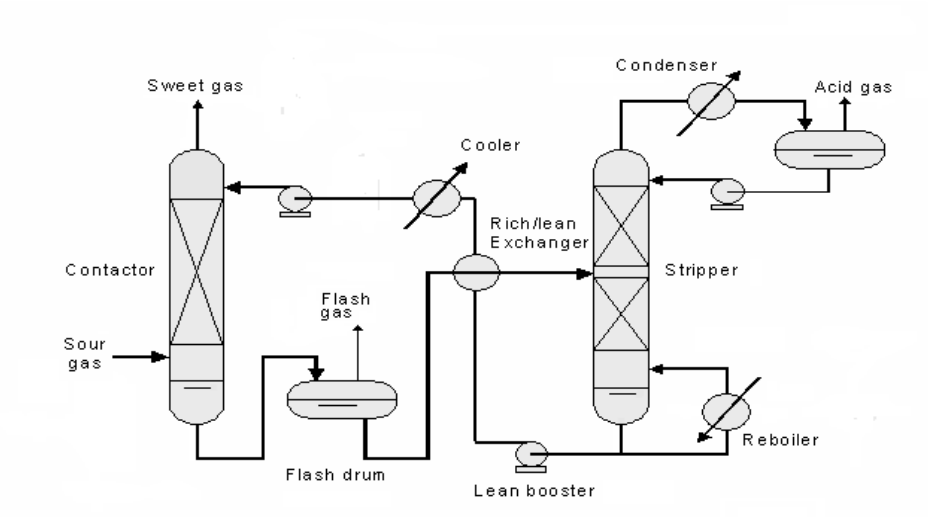
Comparison to Solvent Treating Process

Acid Gas Separation

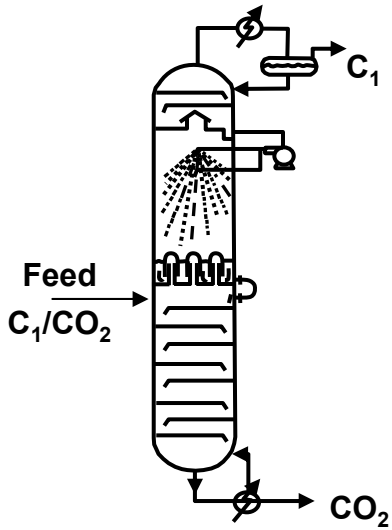
- Normally CO_2 and H_2S are removed by a circulating solvent and are subsequently released as a *low pressure gas* during solvent regeneration, a process that requires *multiple steps* and vessels.

Controlled Freeze Zone™

- Cryogenic separation process without use of solvents.
- Acid gas byproduct stream is liquid.
- No produced gas emissions.



Typical Sour Gas Process

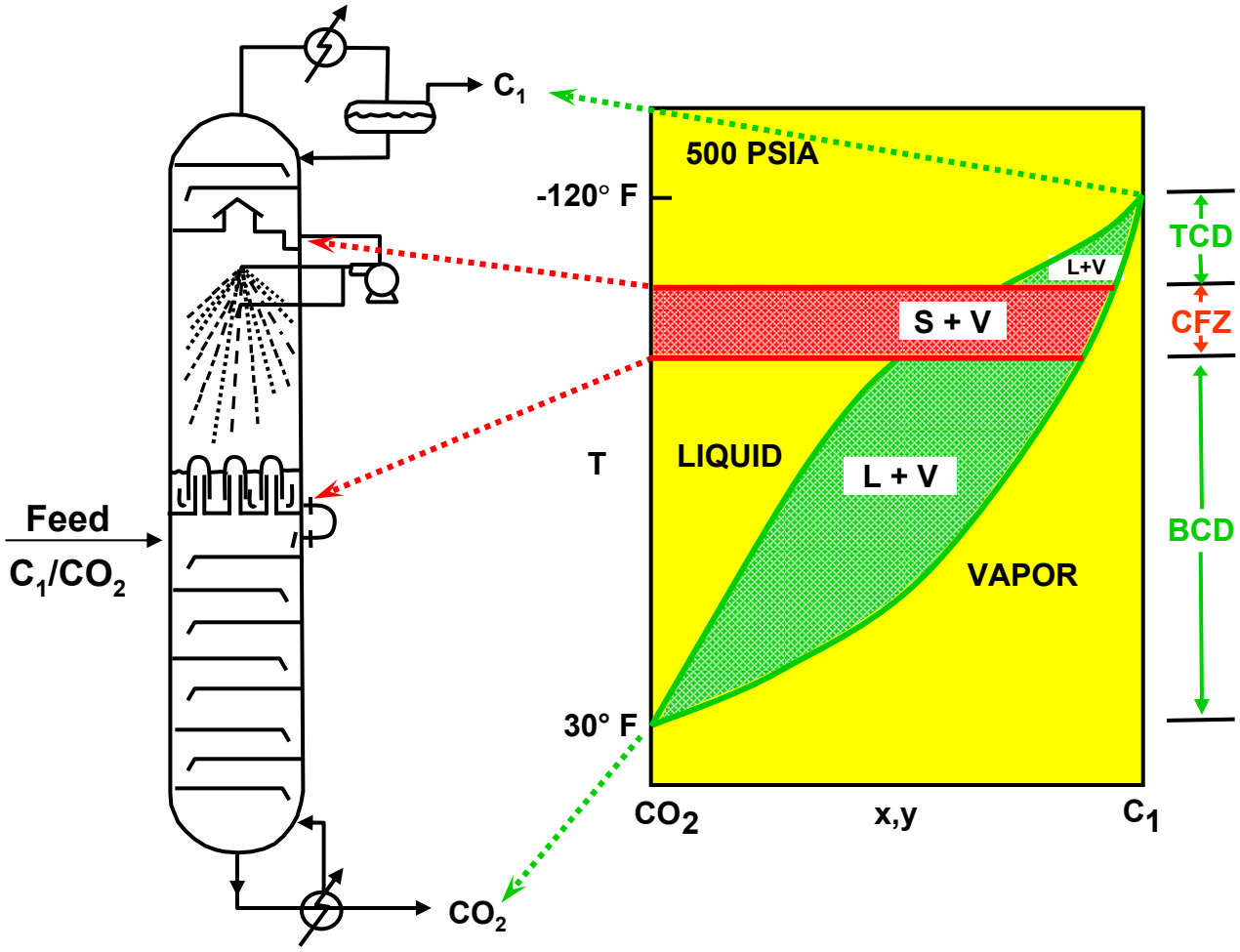


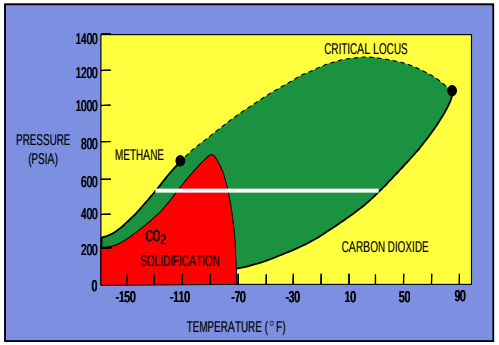
The CFZ™ Solution

Technology Uses a Different Approach

Rather than avoiding solidification of CO_2,

***control* it and *confine* it to specially designed section in distillation column**





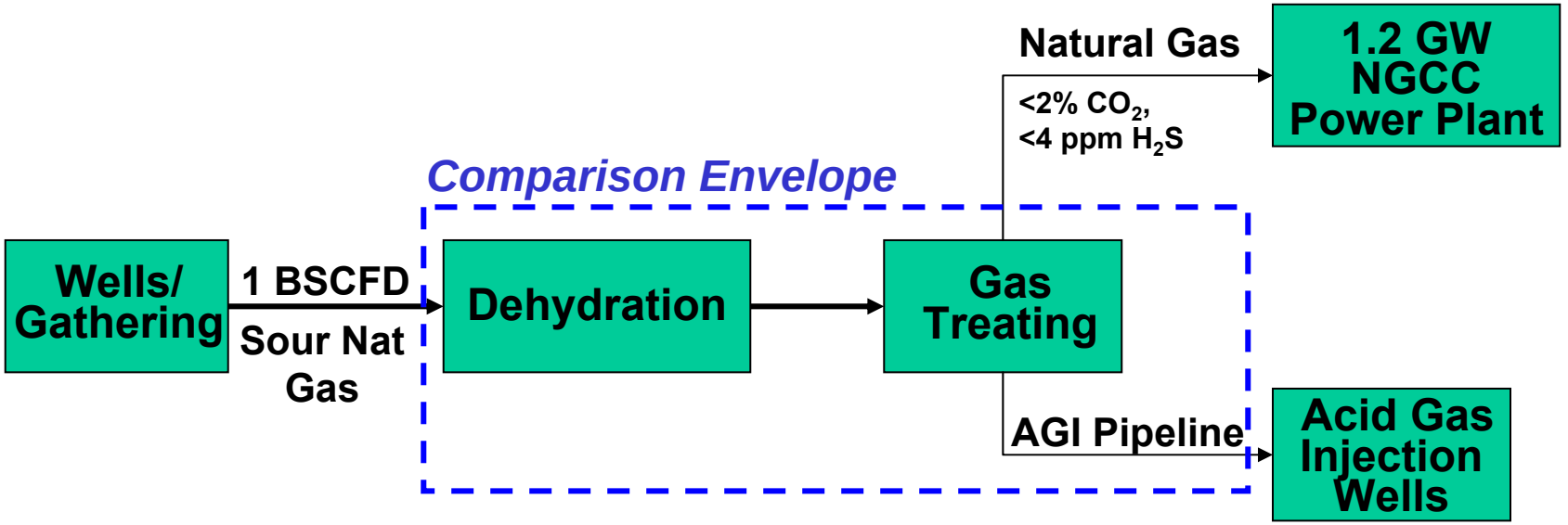
Development of CFZ™ Technology

- **Invented at Exxon Production Research Co. in 1983**
  - **Original U.S. patent granted in 1985**
- **Pilot plant design, construction and operation: 1984-1987**
  - **15 – 65% CO_2; 200 – 600 kscfd**
- **Engineering studies and process improvements 1987+**
  - **Six additional U.S. patents (and associated world patents)**

- **Commercial Demonstration Plant under construction for operation in 2010**
  - **Test wide range of compositions**
  - **Integrated with acid gas injection**
  - **Provide design basis for world-scale plant**

Case Study: Gas to Power Generation

- Comparing Gas Treating Processes on a Consistent Basis



Feed Gas: Sour Natural Gas

Methane: 19%

CO_2: 68%

H_2S: 4%

Gas Treating Options

Base – Selexol™

Alt 1 – Bulk Fractionation + Selexol™

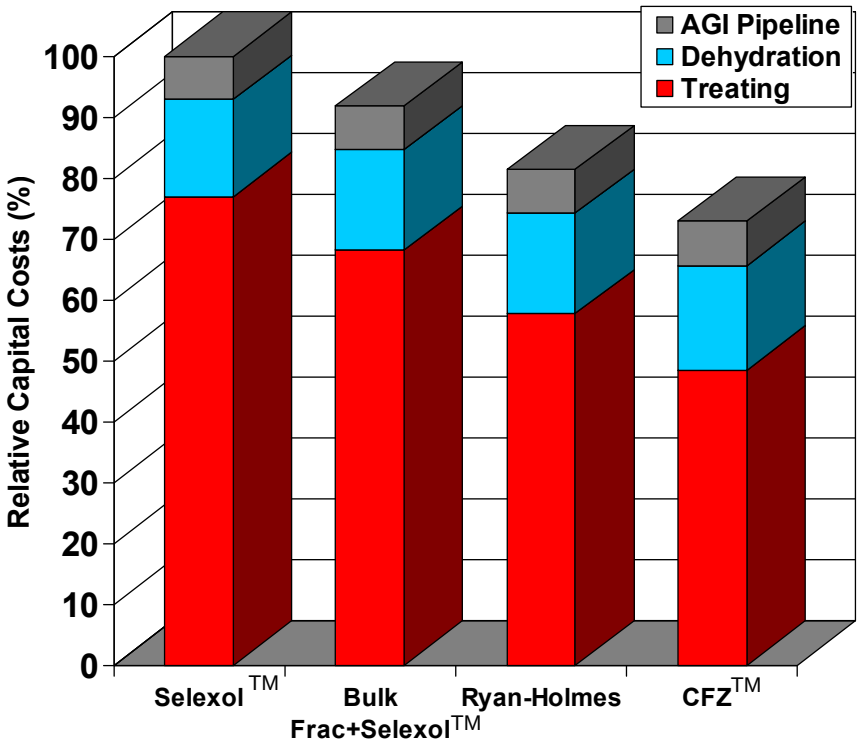
Alt 2 – Ryan-Holmes

Alt 3 – Controlled Freeze Zone™

CFZ™ Advantages:

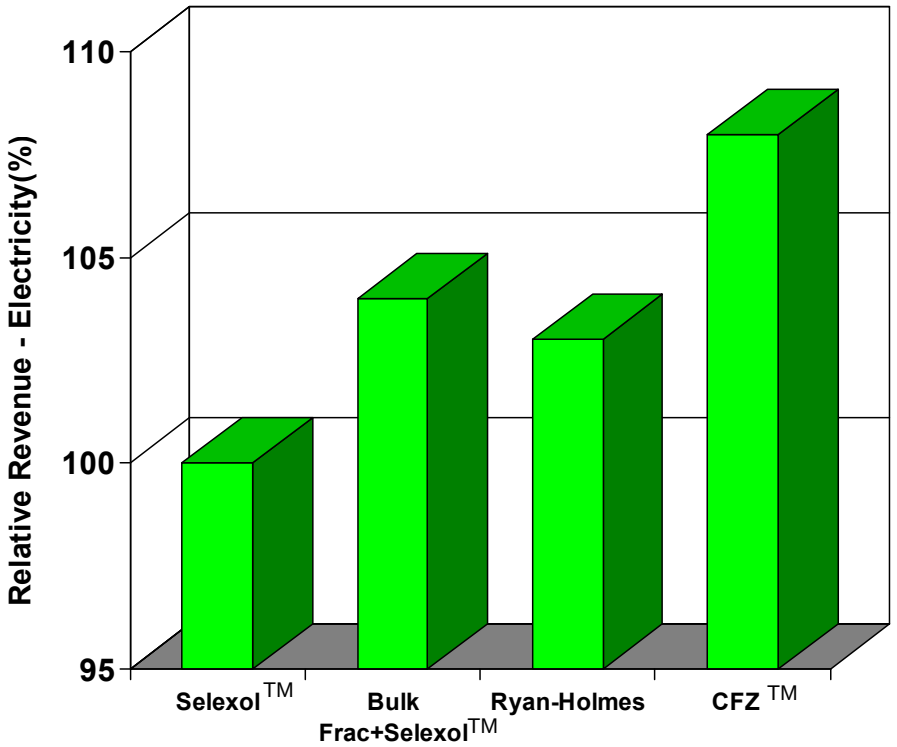
Capital Costs and Process Efficiencies

Overall Costs



- 10 - 27% lower overall capital costs
- 12 - 37% cost savings for treating

Electricity Sales Revenue



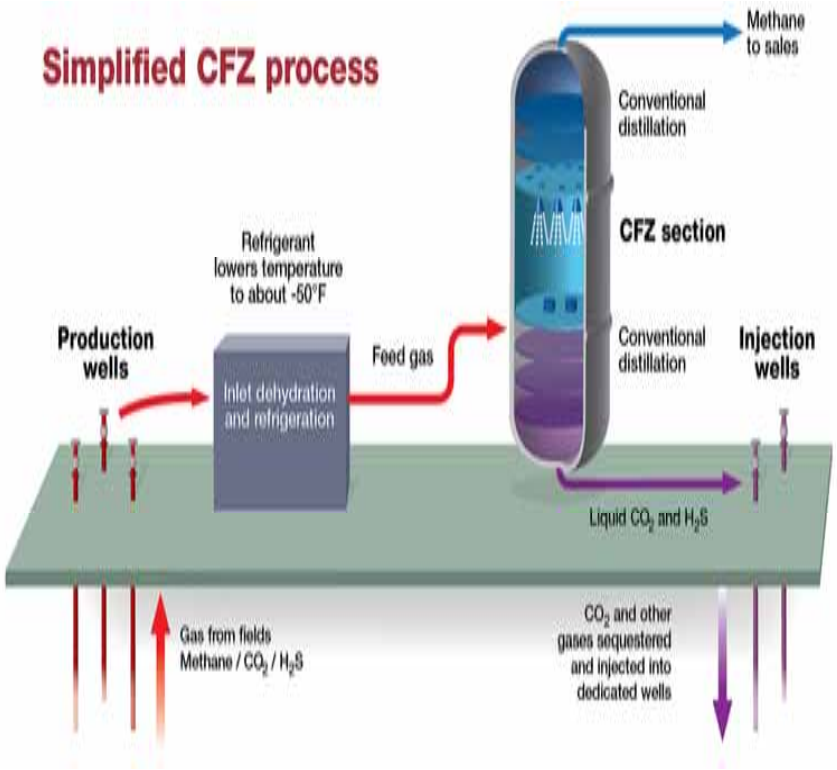
- 5 - 16% less natural gas required
- 4 - 8% greater revenue from sales

Simpler Process, Fewer Processing Steps – Less Equipment

Overall Greater Process Efficiency in Integrated Configuration

CFZ™ Technology Incentives

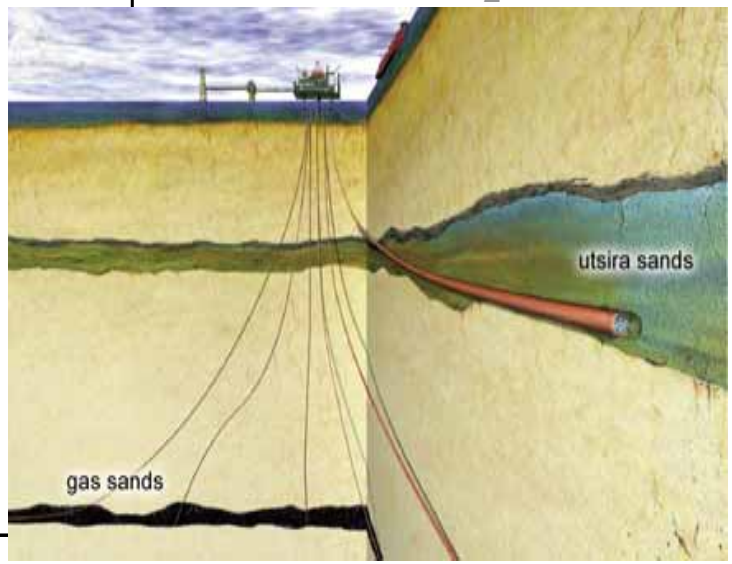
- **Significant capital and operating expense savings**
  - Fewer processing steps ➔ Less equipment for all applications
  - Reduction or elimination of solvents and additives
  - Lower acid gas injection costs
    - + High pressure separation
    - + Liquid acid gas stream can be pumped for reinjection vs. costly compression
- **Greater profitability ➔ Less costs, greater process efficiencies, greater revenue**
- **Environmental benefits:**
  - Allows economic CO_2 geosequestration or EOR
  - Provides alternative for sulfur plants



The Higher the Acid Gas Content, the Greater the Benefits

ExxonMobil Acid Gas Injection Experience

Sleipner CO_2 Injection



O. Kaarstad, Statoil IEA 2004

- **ExxonMobil leads the industry in designing and operating large-scale Acid Gas Injection (AGI) projects**

- **Sleipner CO_2 injection underway since 1998 (10 million tonnes CO_2)**

Closing:

Connecting Gas Treating to Carbon Capture

- **Carbon capture and storage (CCS) could play a significant role in helping to reduce CO_2 emissions from the use of fossil fuels**

- **Technology components for CCS practiced in oil and gas industry**
  - **Removal of CO_2/H_2S from natural gas with processes like Controlled Freeze Zone™**
  - **Transportation via pipeline**
  - **Disposal via acid gas or sour gas injection**
  - **Use in Enhanced Oil Recovery**

- **Transfer experience of operating large recovery, treating, and injection facilities to facilitate technology advancements**

- **Challenge: Integrate these components into a single large scale system in a different industry while addressing costs and regulations**

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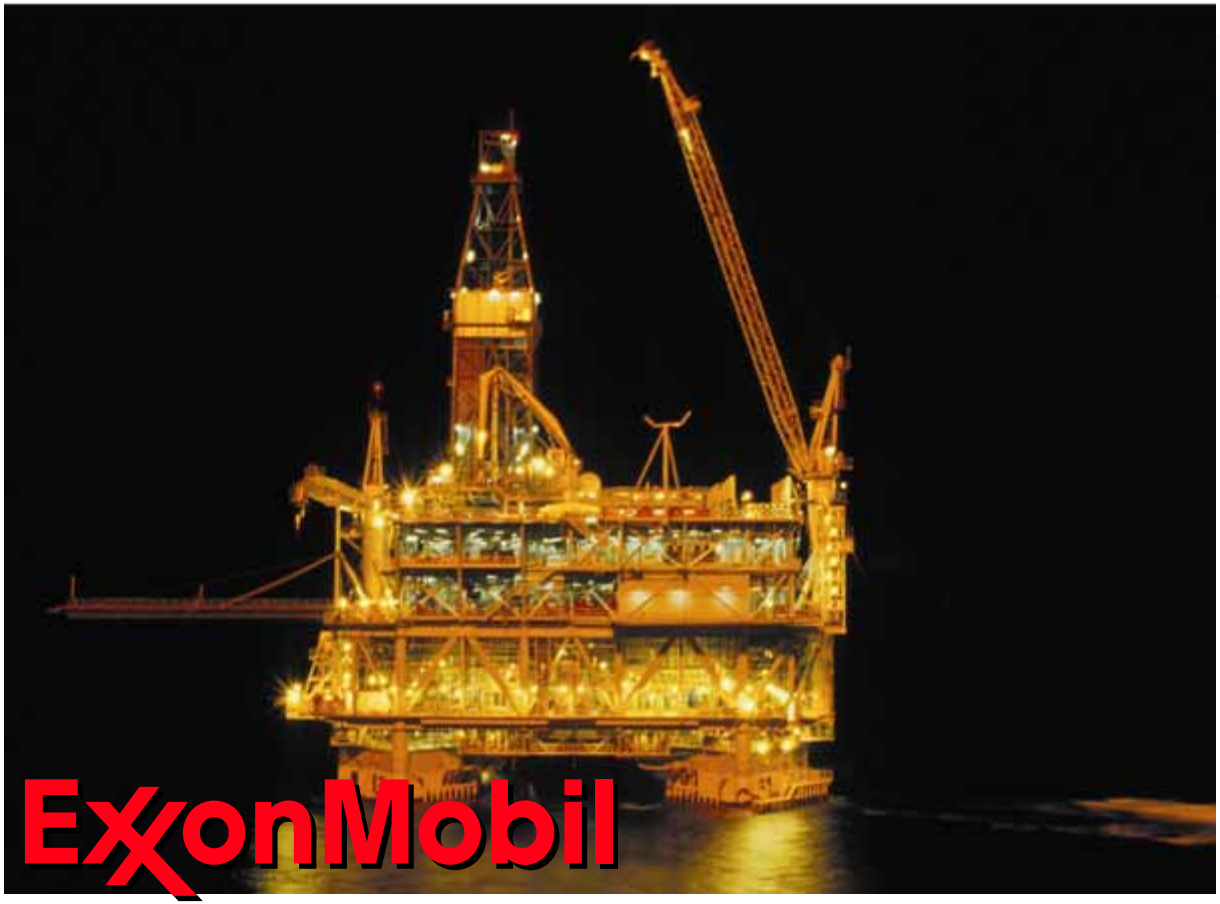
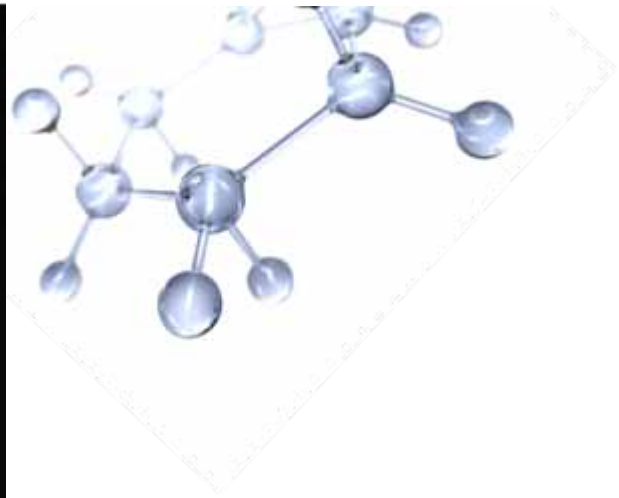
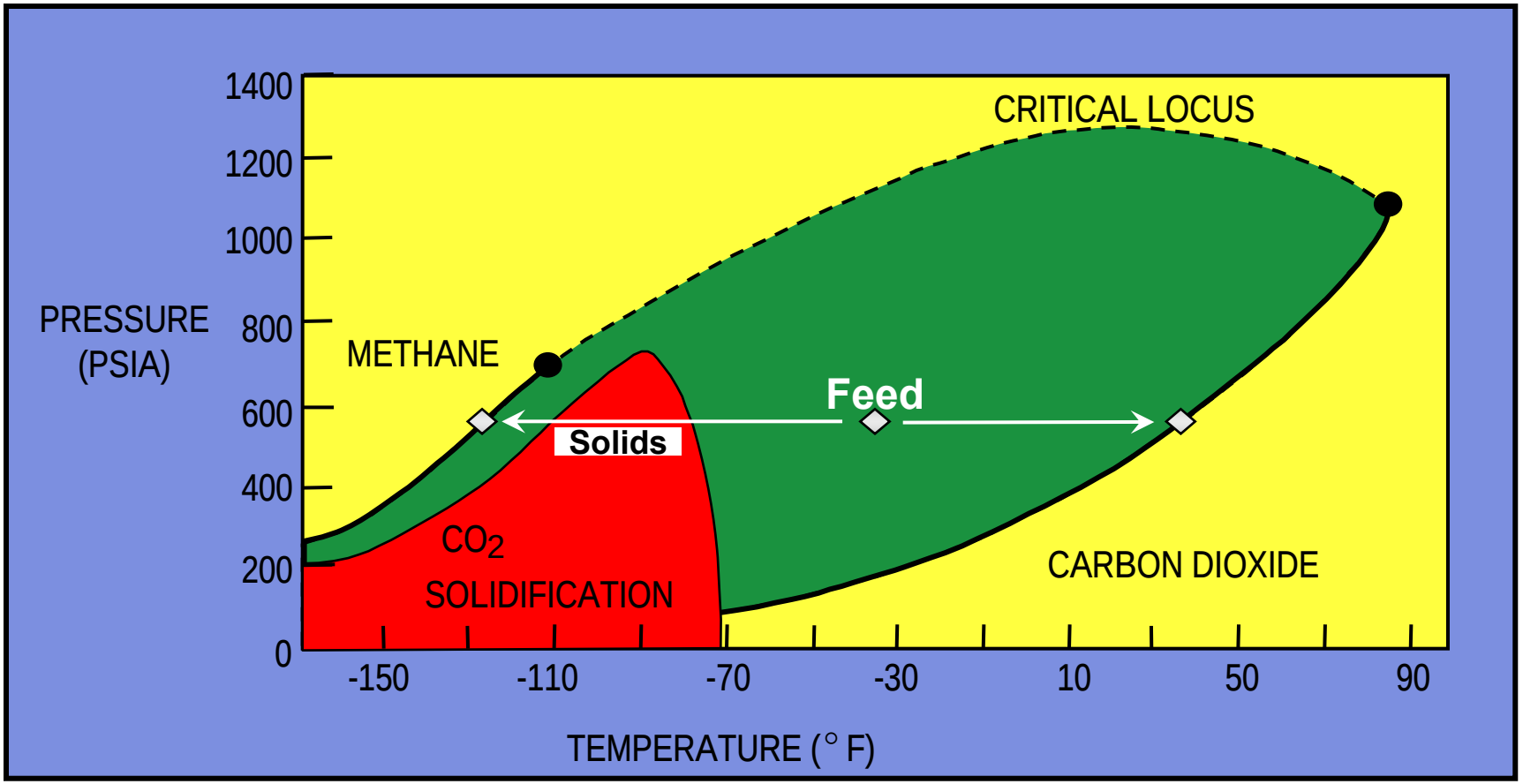




Taking on the World's Toughest Energy Challenges.™

Thermodynamics: Methane – CO_2 System

Thermodynamic Basis for Separation of CO_2 from Methane



Separation requires crossing the solidification zone for methane sales purity product