Cryogenic CO_2 Capture – Cost-Effective CCS

Larry Baxter, Stephanie Burt
Brigham Young University

Andrew Baxter
Sustainable Energy Solutions

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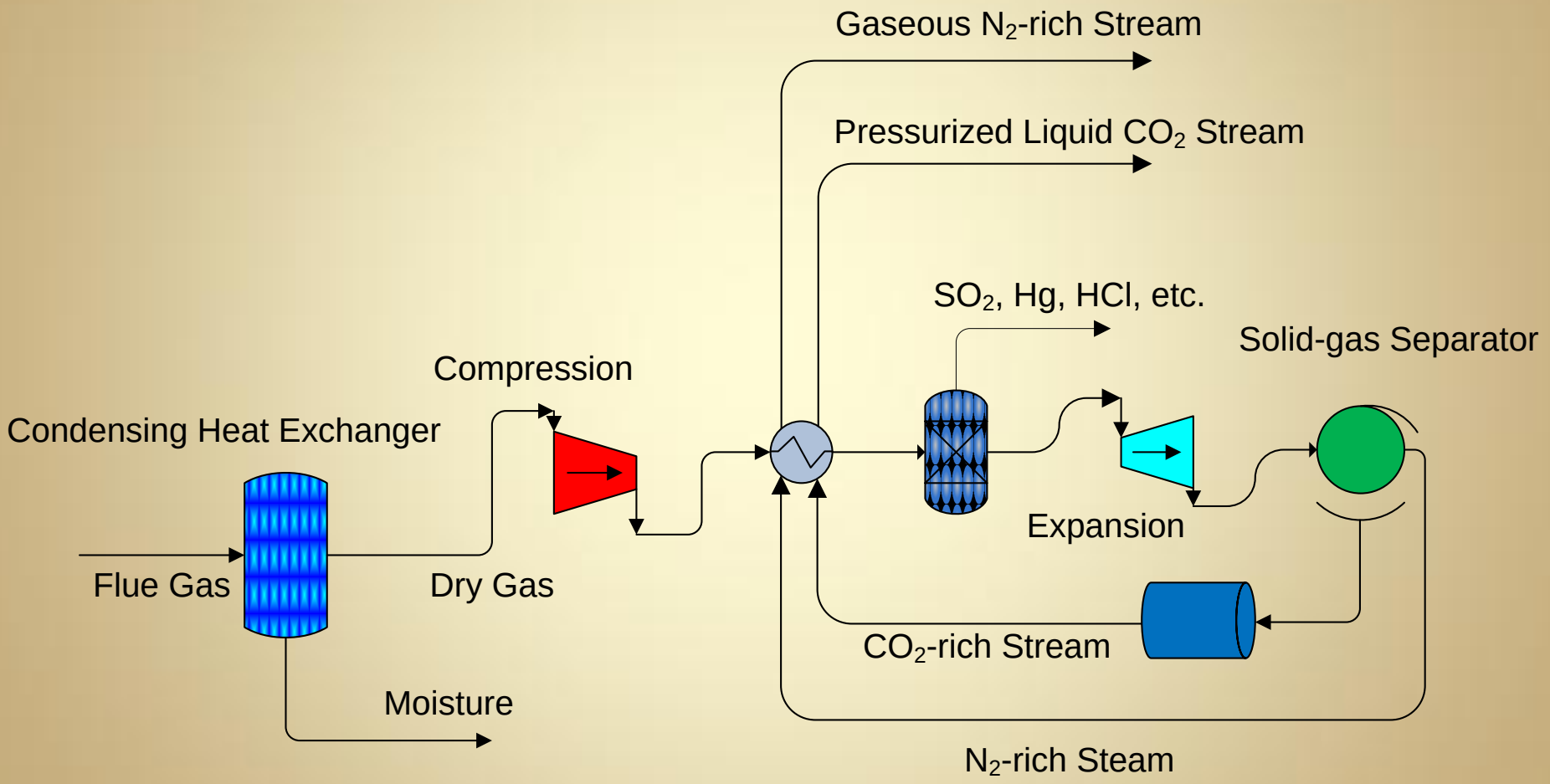
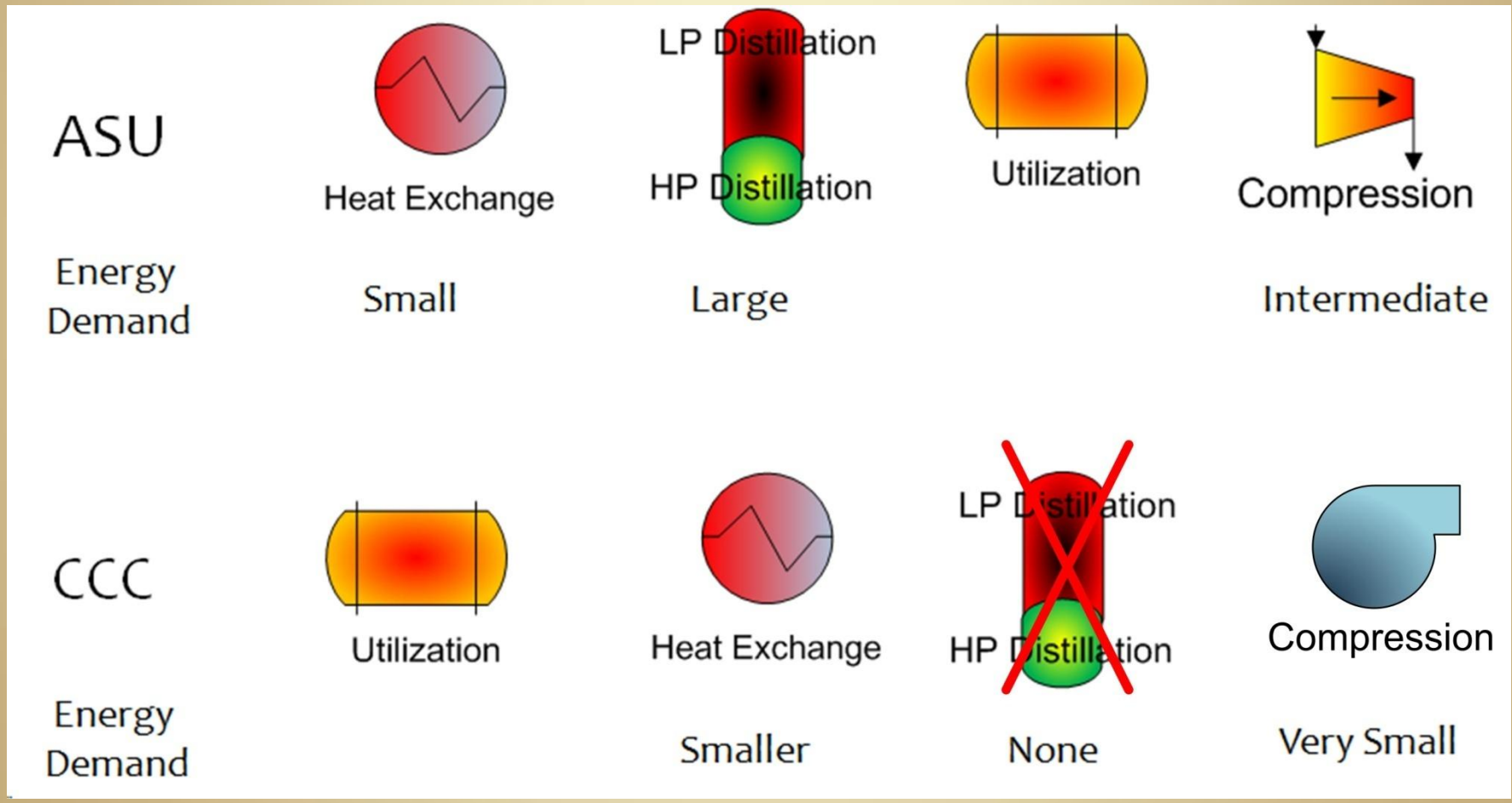
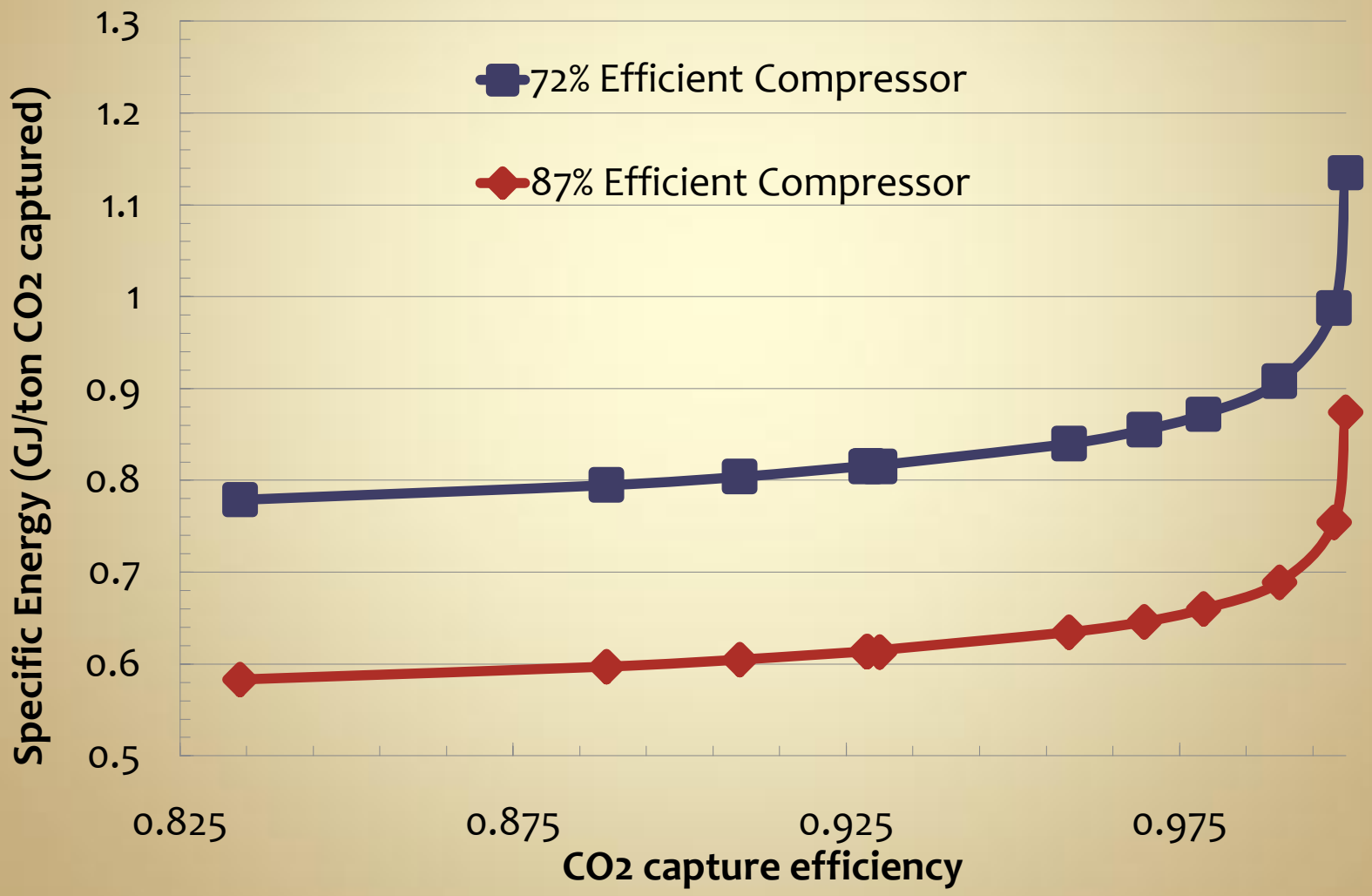
Cryogenic CO_2 Capture - I



ASU Comparison



Energy Efficiency

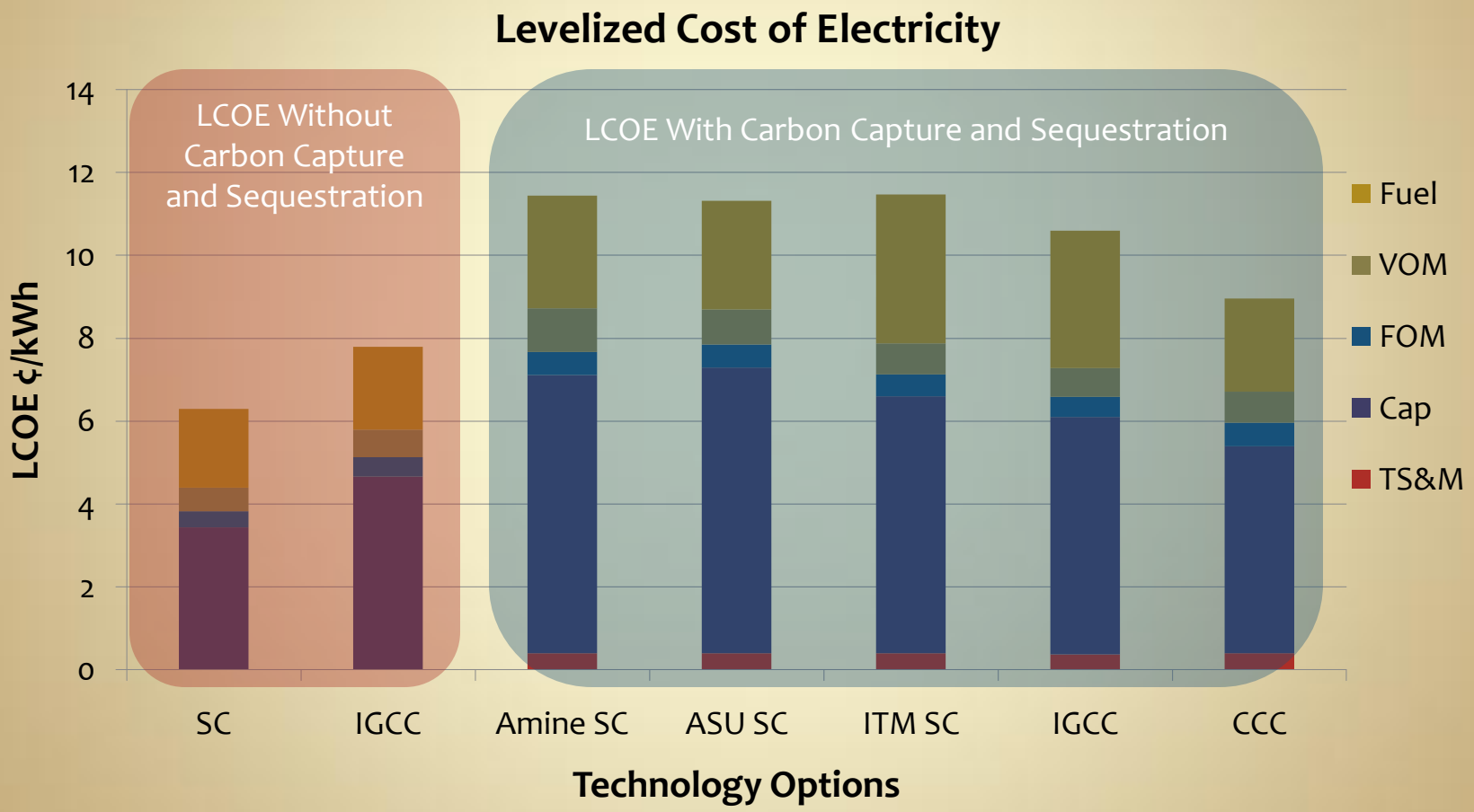


Plant Integration Advantages

(Not Accounted for in Cost Comparisons)

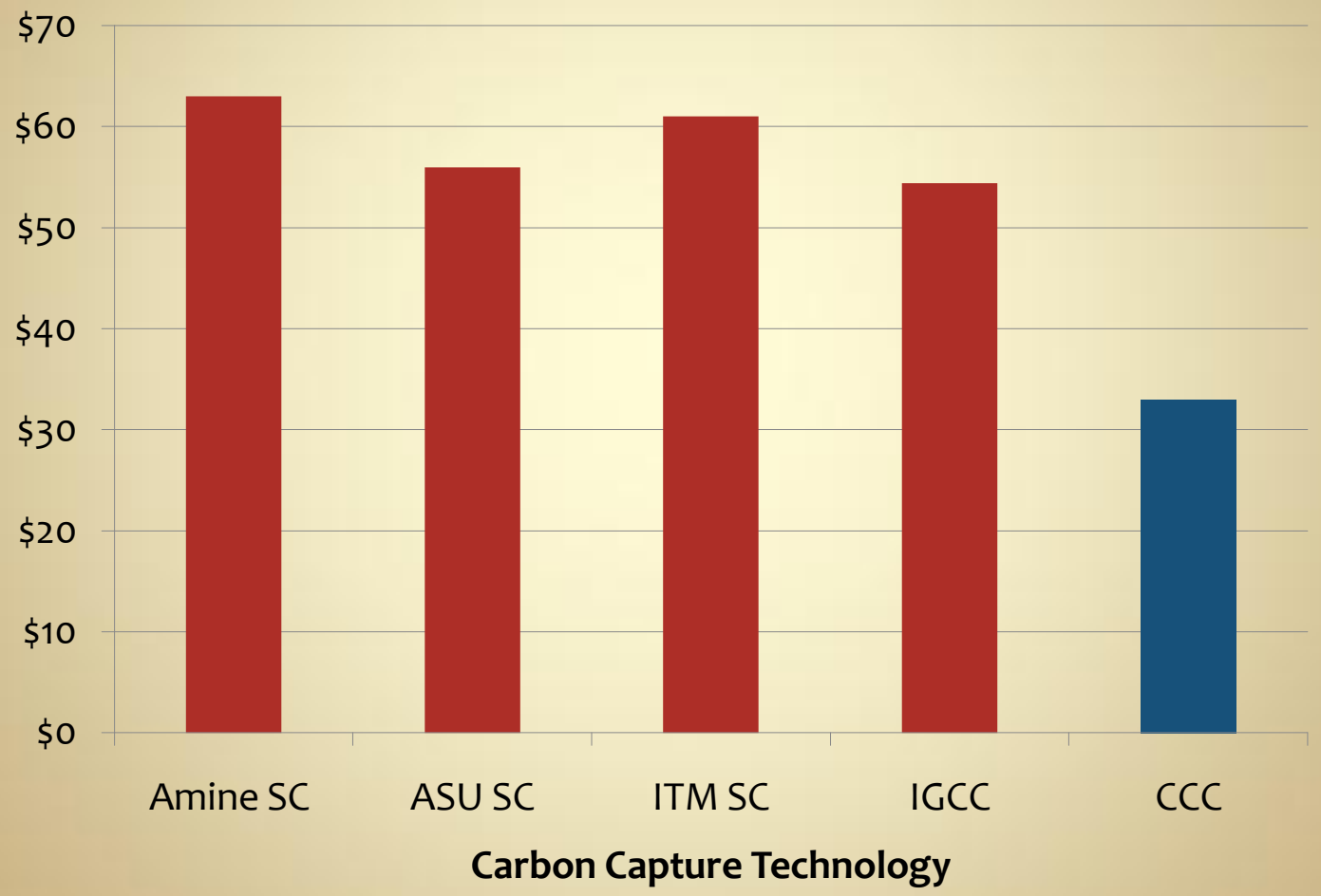
- Replaces/reduces SO_2 and NO_x treatments (additional 25-30 % capital and non-fuel operating cost reduction)
- Stores and regenerates energy (minimizes or avoids new plant construction)
- Retrofits existing systems with minimal boiler modification (possibly reduces new permitting and leverages legacy boiler investments)
- Provides inherent low temperature stream (decreases turbine outlet temperature for better efficiency and reduces cooling water requirements)
- Recovers water in usable form

Levelized Cost of Electricity



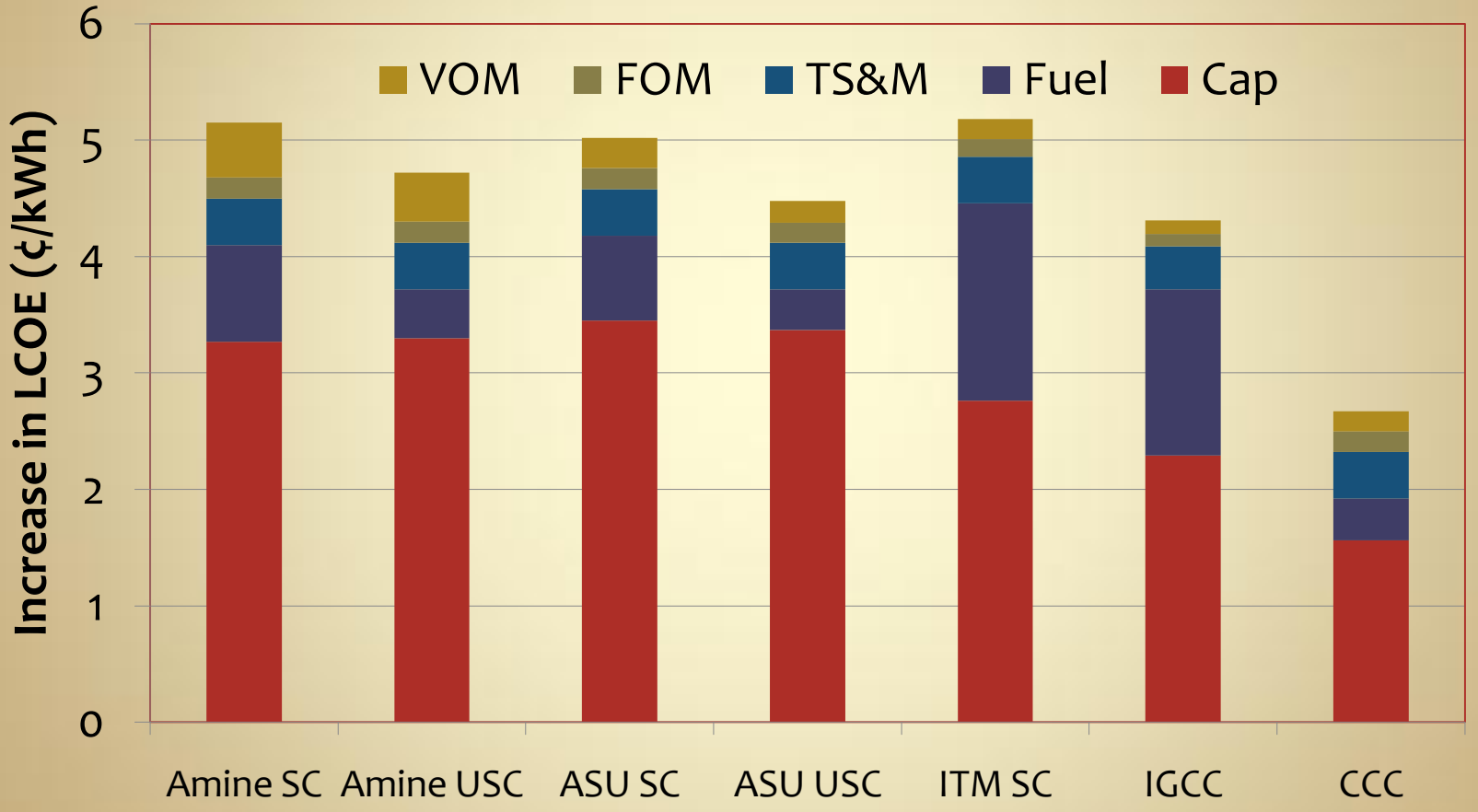
Data for all non-CCC systems computed by DOE (2007) using same software.

Cost per Avoided Ton of CO_2

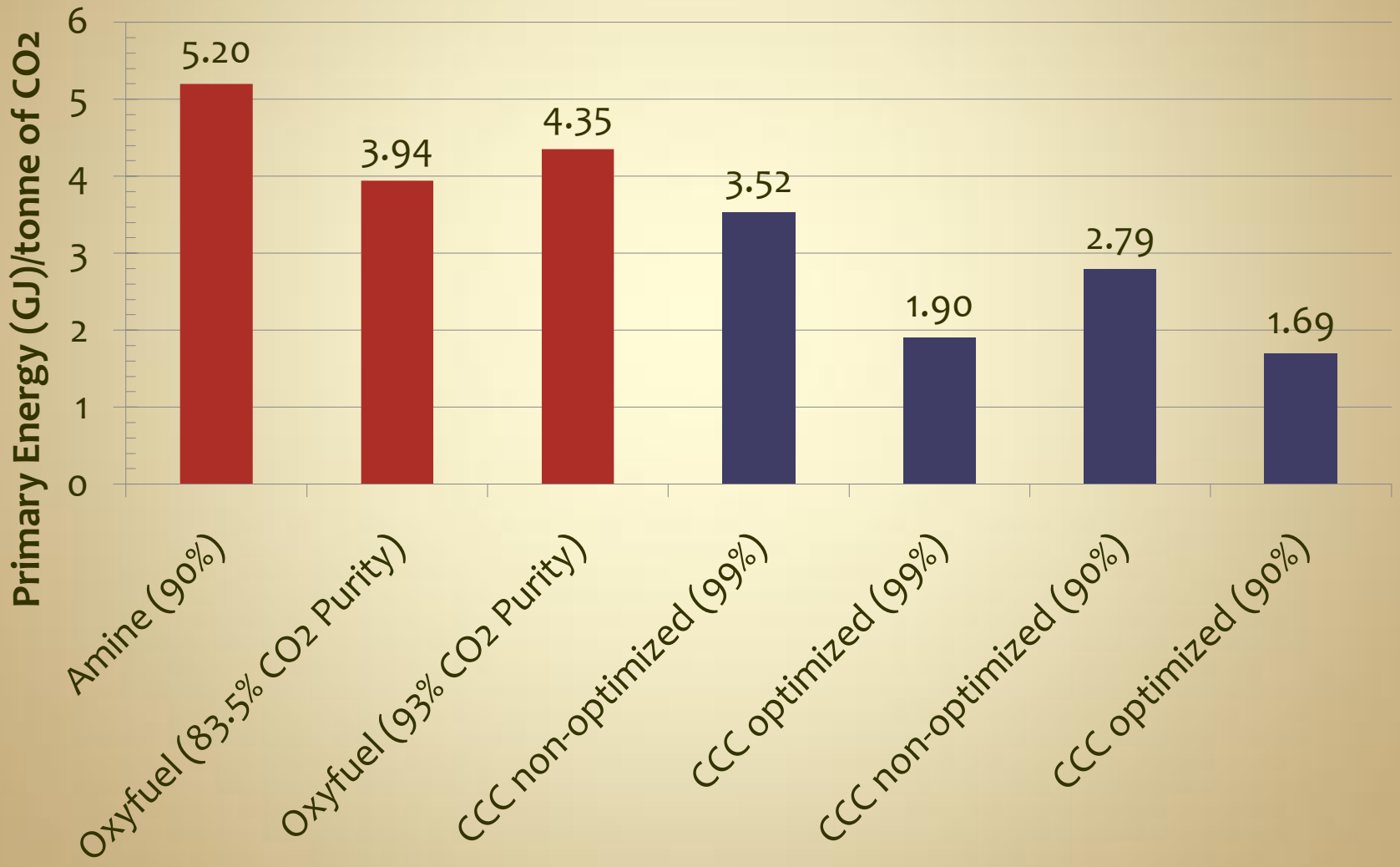


Data for all non-CCC systems computed by DOE (2007) using same software.

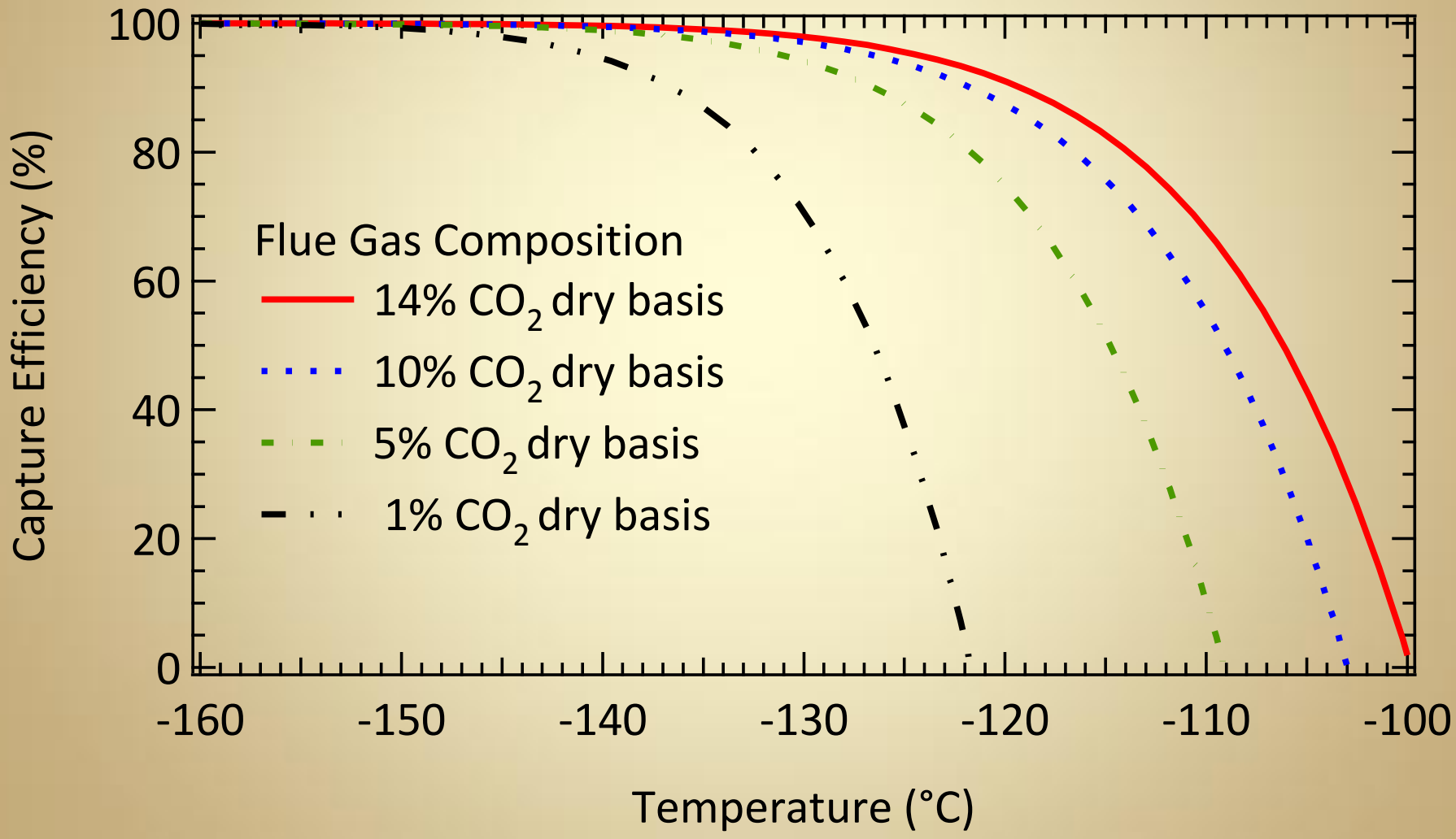
Marginal Cost Increases



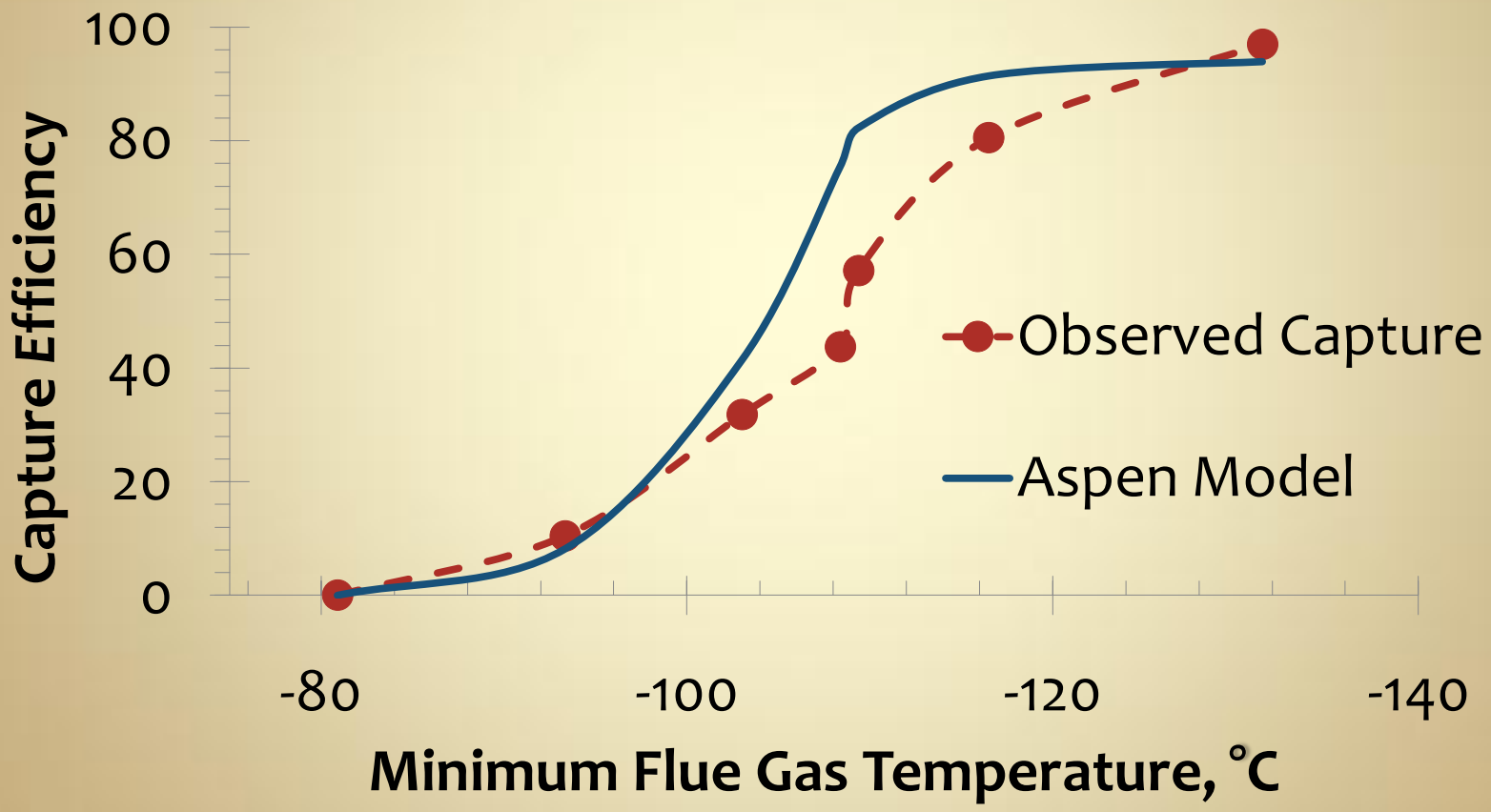
CCC vs Alternatives



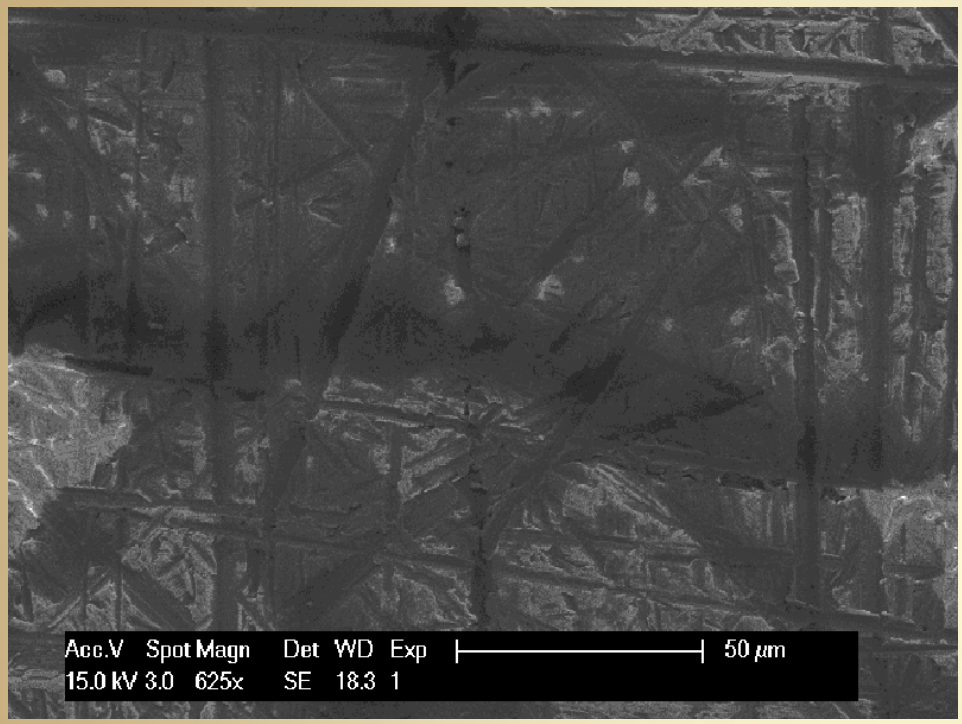
Capture Efficiency at 1 atm

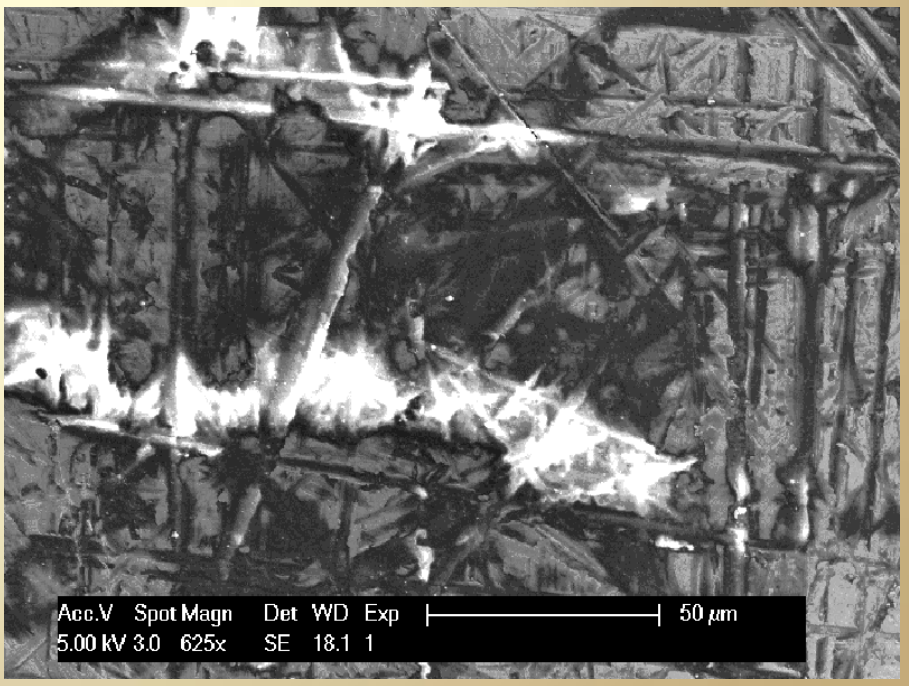


Capture Efficiency

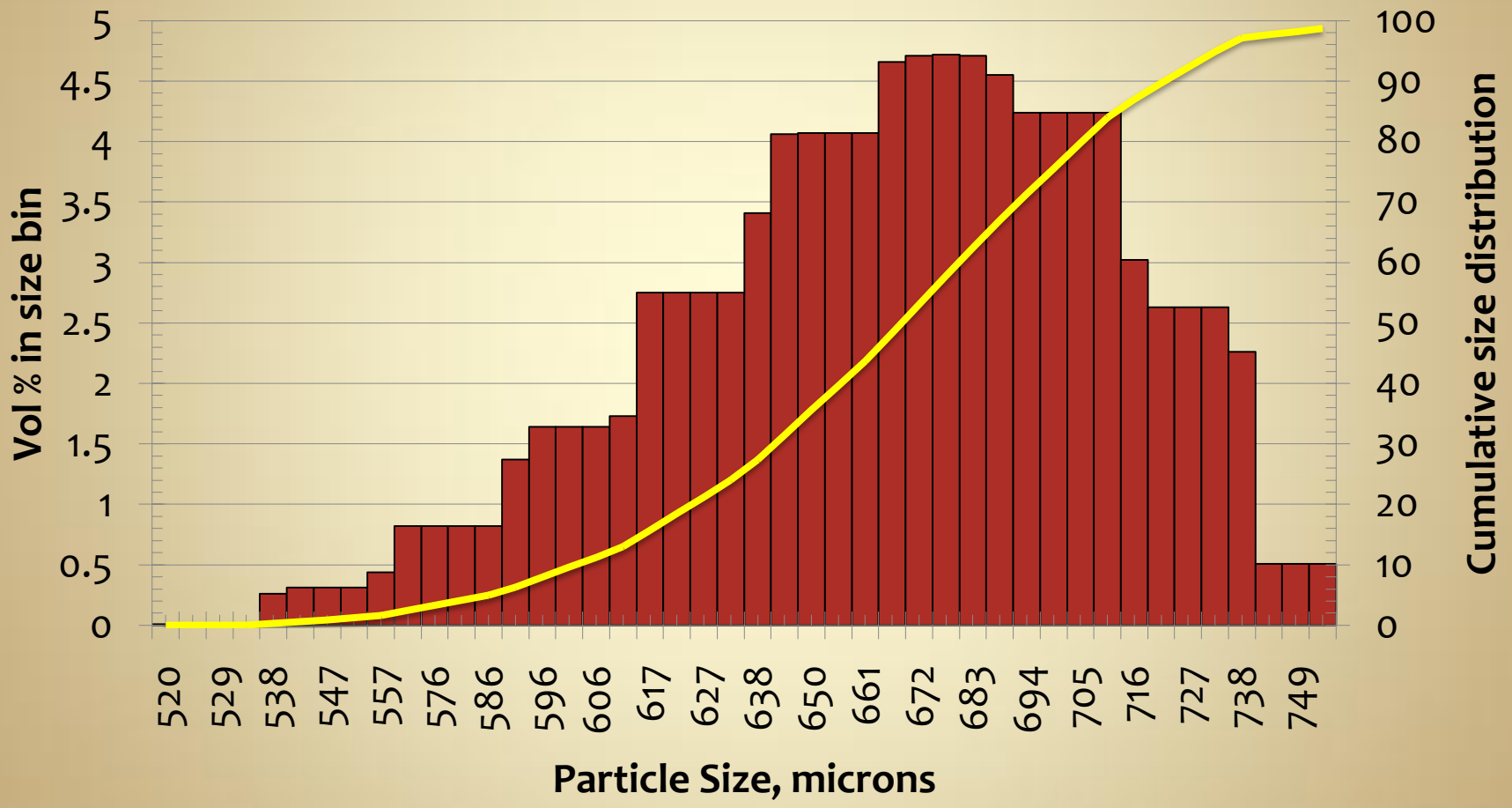


Materials Tests

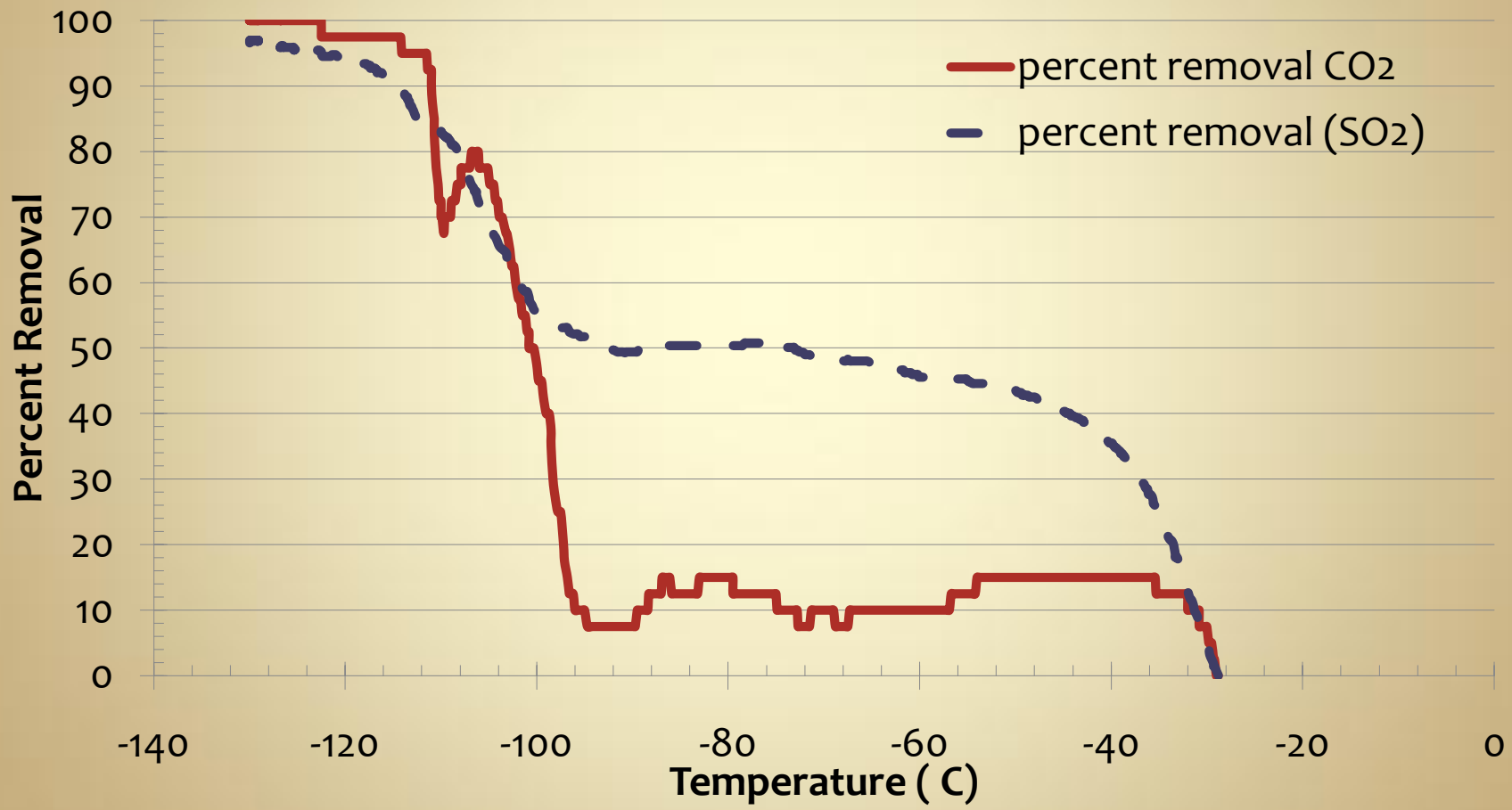




CO_2 psd


Vol % in size bin
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Cumulative size distribution
0
10
20
30
40
50
60
70
80
90
100
520
529
538
547
557
576
586
596
606
617
627
638
650
661
672
683
694
705
716
727
738
749
Particle Size, microns

Preliminary Experimental Data



Commercial Benefits

- CO_2 Separation 40% Cheaper and With Less Energy Cost than Alternatives
- Bolt-On Technology
- Major Plant Integration Advantages
- System Compatibility

Acknowledgements

- Rachel Stevenson, Jacob Larsen, Doug Parker, Grant Evans, Shawn Kunzler, David James, Jacob Jones, Scott Greenwood, Chris Bence
- Dong Energy, CRE Energy

Plant Integration Advantages

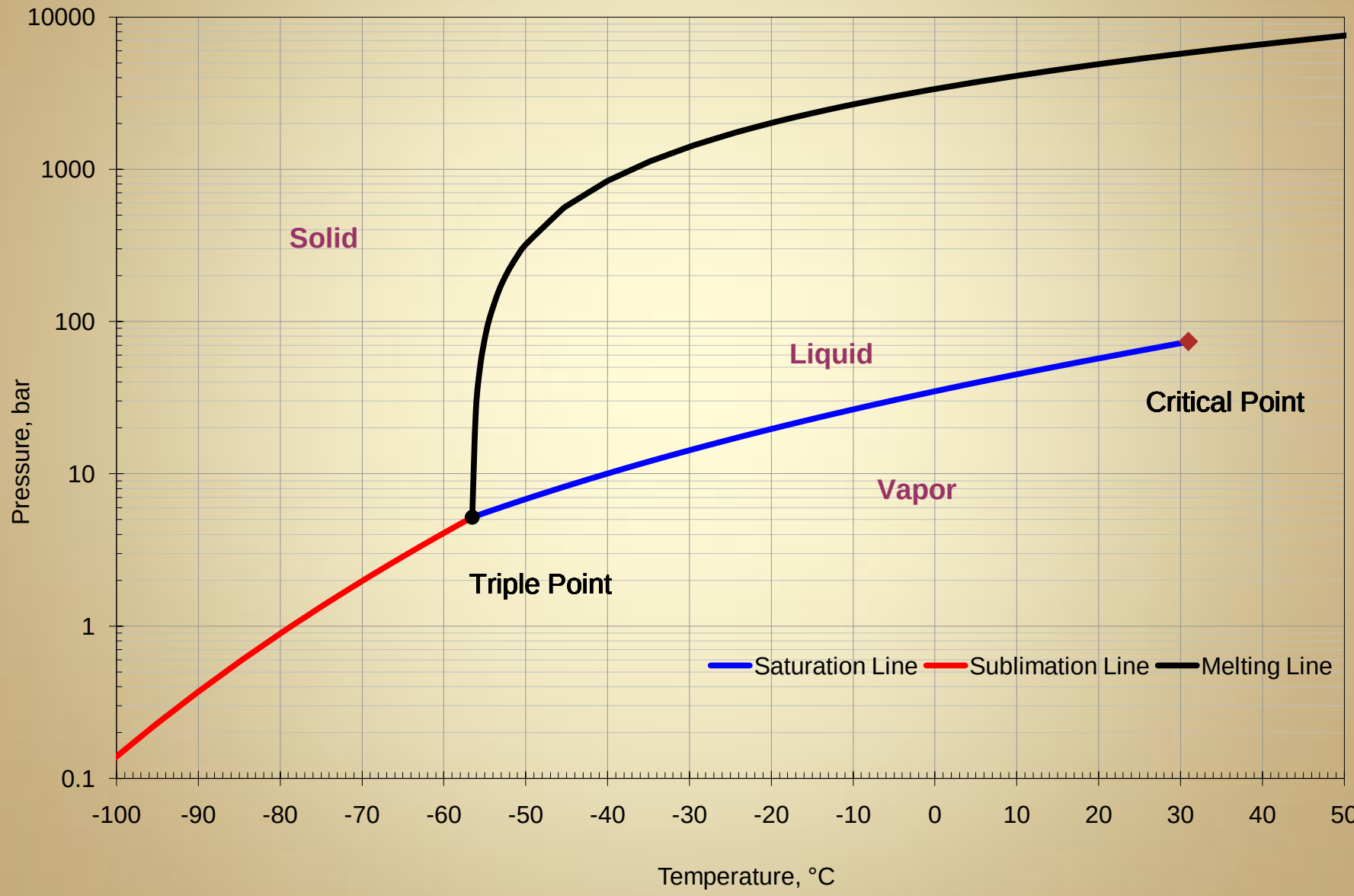
(Not Accounted for in Cost Comparisons)

- Replaces/reduces SO_2, Hg, HCl, NO_2 and possibly NO_x treatments
- Can store and regenerate energy efficiently (minimizes or avoids new plant construction)
- Retrofits existing systems with minimal boiler modification (possibly reduces new permitting and leverages legacy boiler investments)
- Provides inherent low temperature stream (decreases turbine outlet temperature for better efficiency and reduces cooling water requirements)

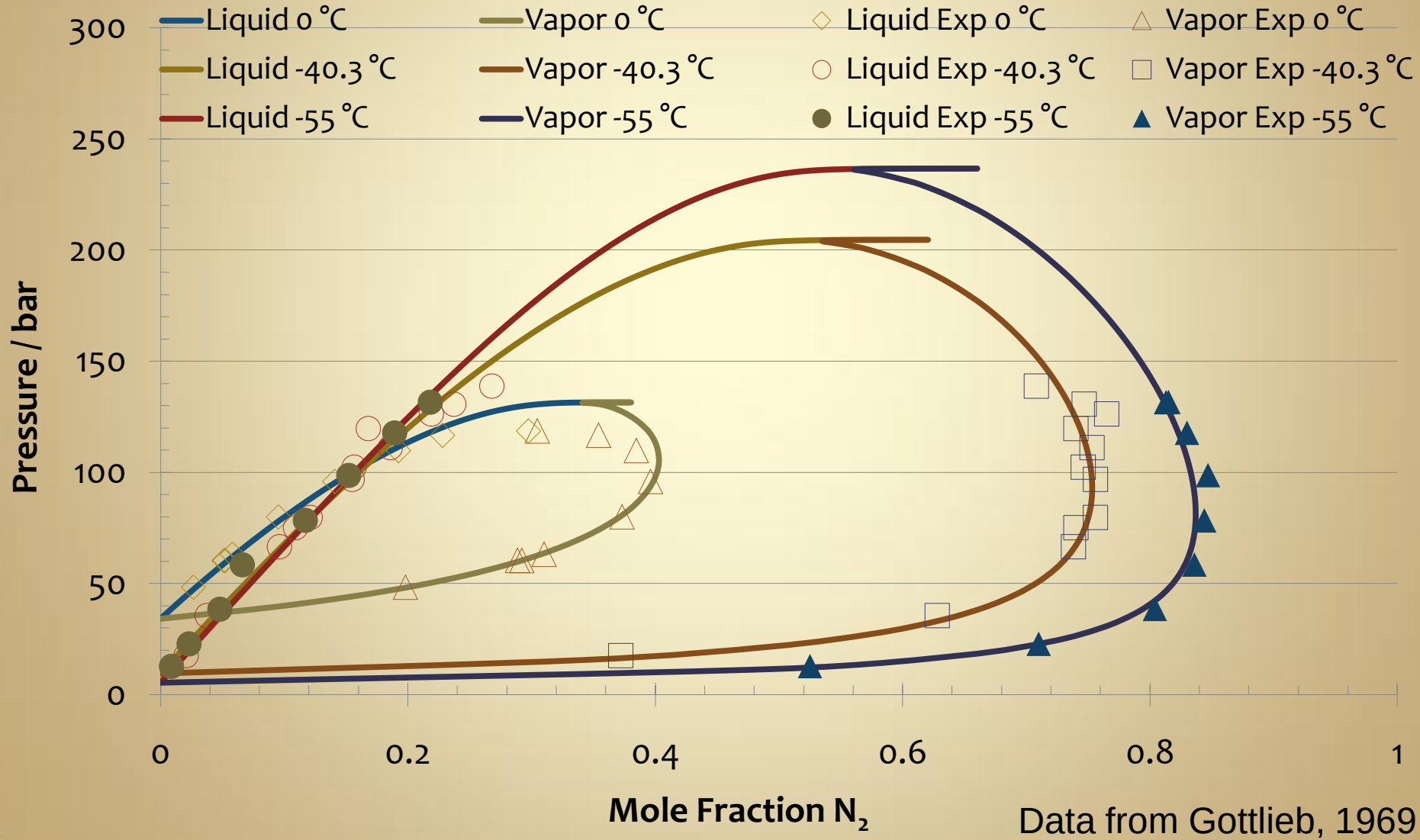
Current Efforts

- Laboratory experiments and demonstrations
- Bench-scale, integrated operation
- Preparing or submitted proposals for skid-scale and pilot-scale systems

CO_2 Phase Diagram

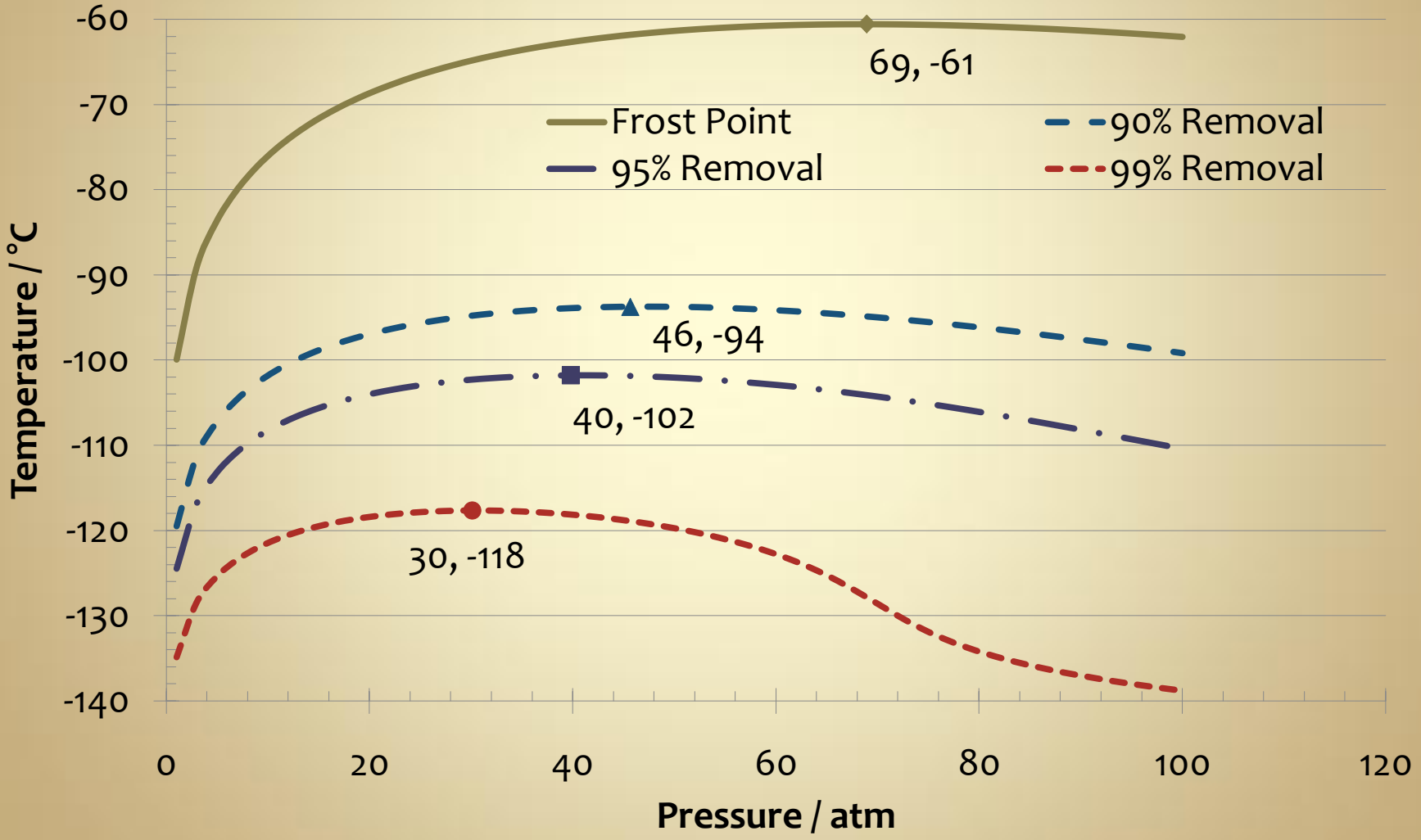


Liquid CO_2 Thermodynamics



Data from Gottlieb, 1969

Solid CO_2 Thermodynamics



Data for typical flue gas composition (13.5% CO_2, 3% O_2, 100 ppm SO_2 and NO, balance N_2)