Fourth Annual Conference on Carbon Capture & Sequestration

Developing Potential Paths Forward Based on the Knowledge, Science and Experience to Date

Capture and Separation- Oxyfuel Combustion

CO_2 Compression Units for Oxy-Fuel Combustion

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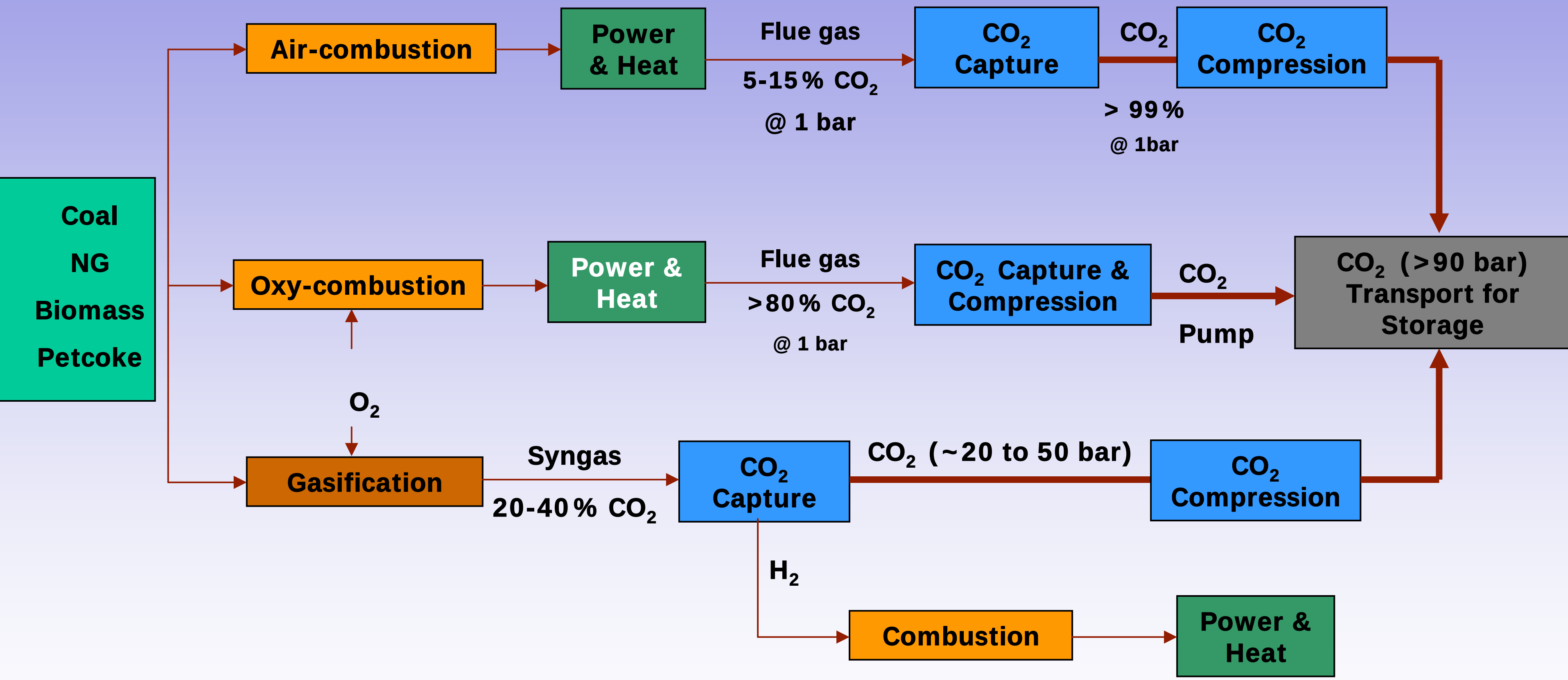
May 2-5, 2005, Hilton Alexandria Mark Center, Alexandria Virginia

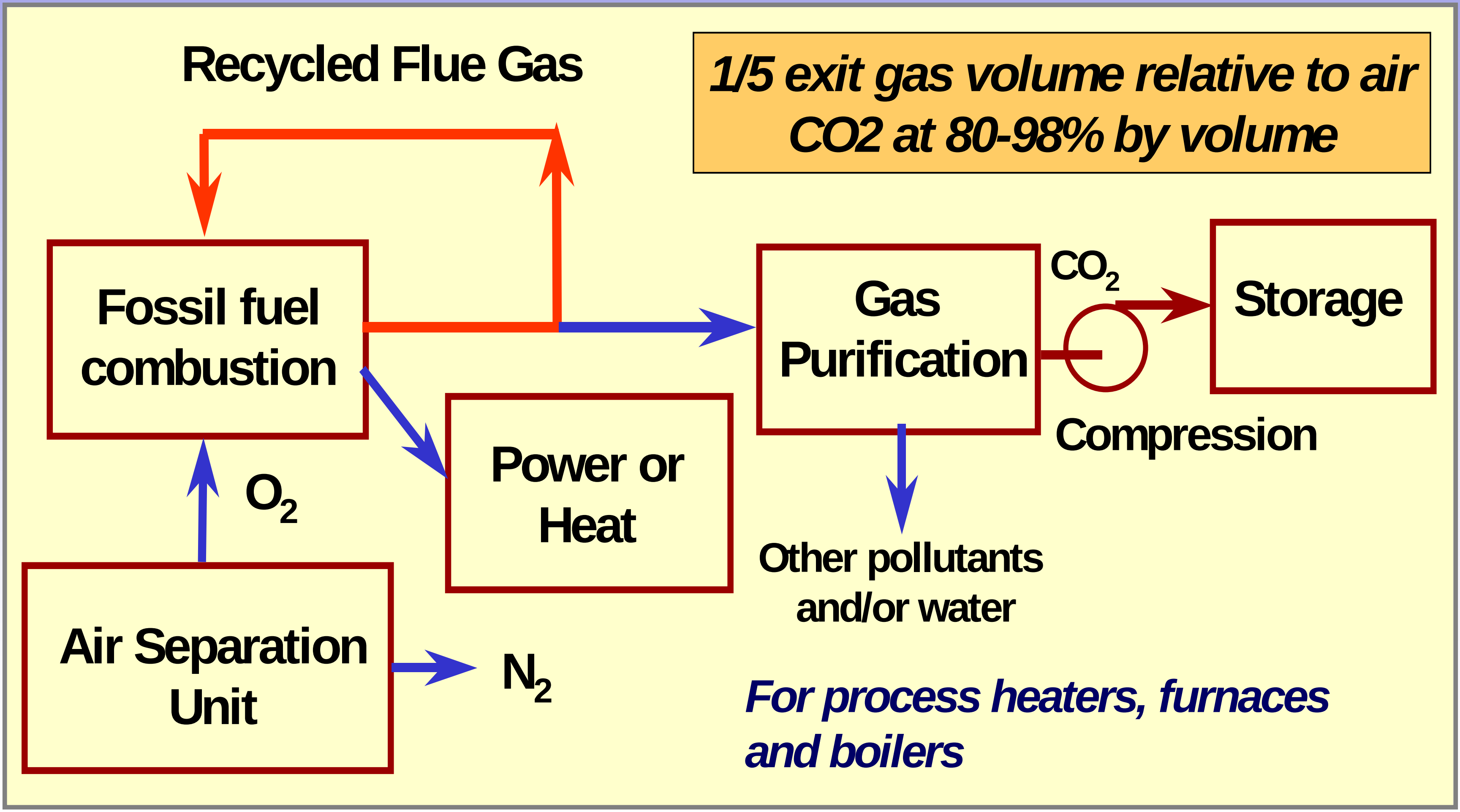
Outline

- Fuel combustion and CO_2 capture pathways
- Oxy-fuel Combustion
- CO_2 compression and capture processes
  - Once-through process
  - Autorefrigeration (Fluor process)
  - Novel CETC process
- Pretreatment and moisture separation
- Process modeling and simulation
- Results
- Conclusions

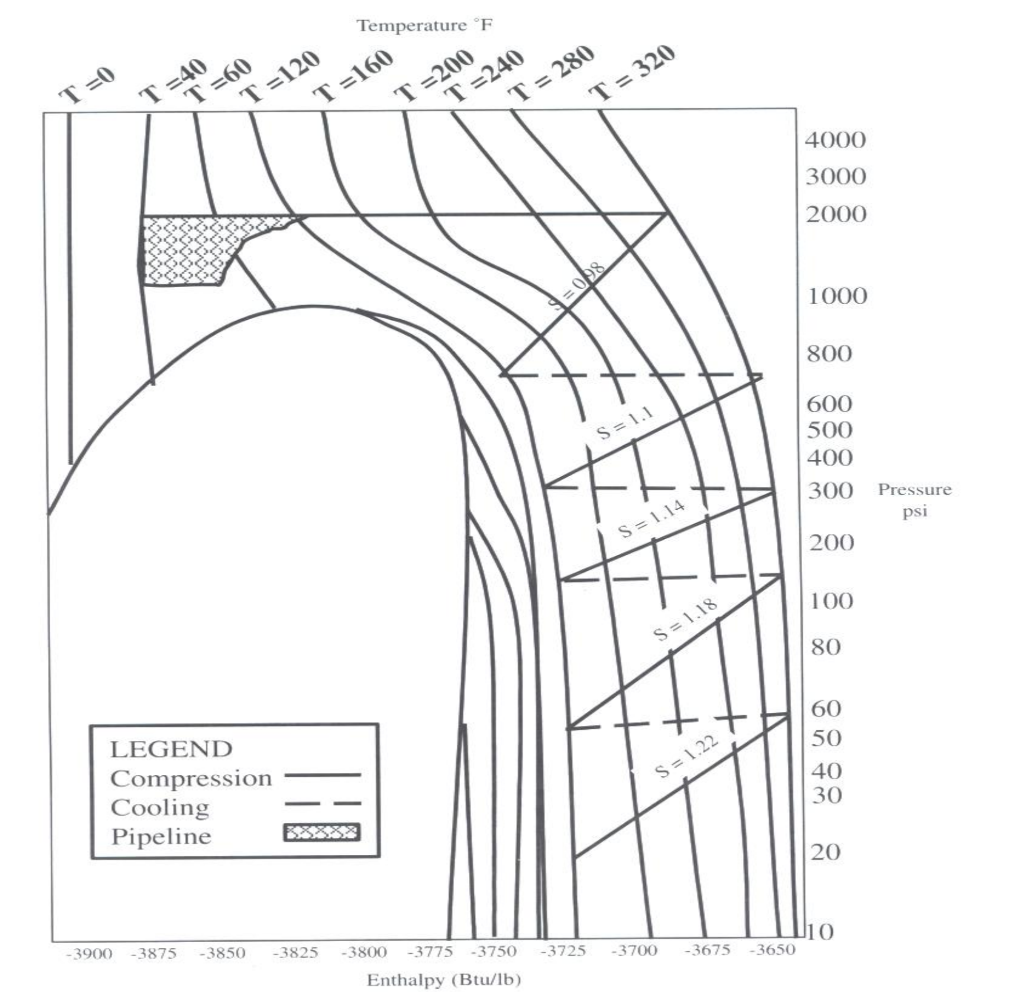
Capture Pathways



Schematic of Oxy-Fuel Combustion for Power or Heat Generation

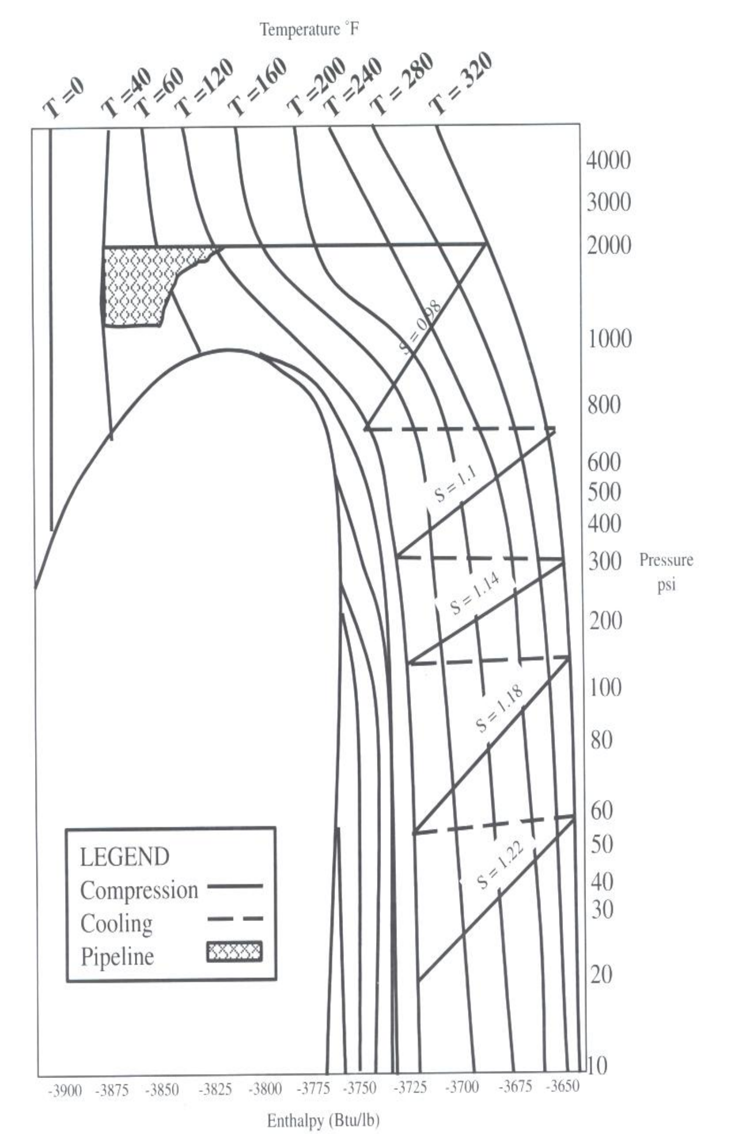


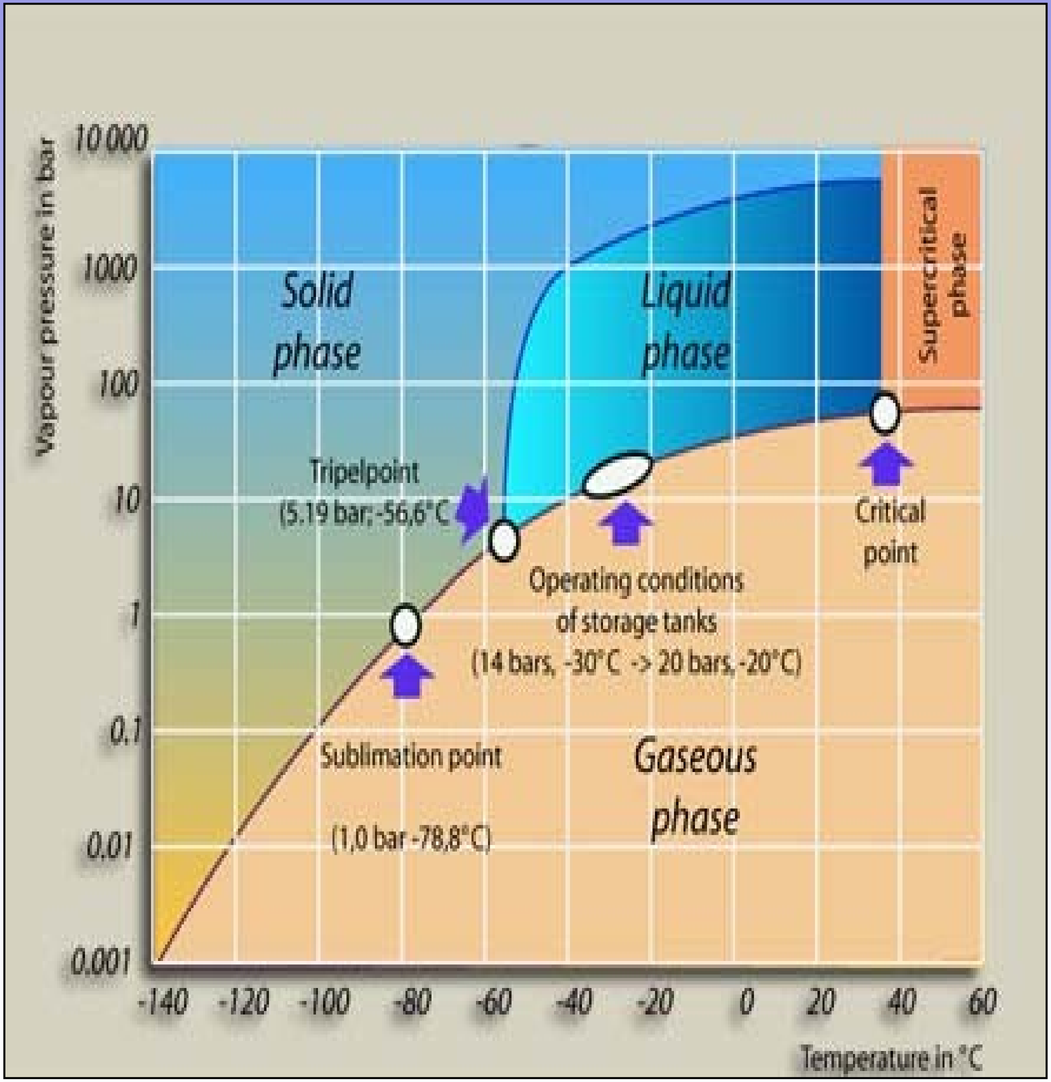
An Idealized Thermodynamic Path of Compression, Cooling, and Pipeline Operations for CO_2



Mohitpour M., Golshan H., and Murray A., Pipeline Design and Construction: A Practical Approach, New York, American Society of Mechanical Engineers Press, 2000

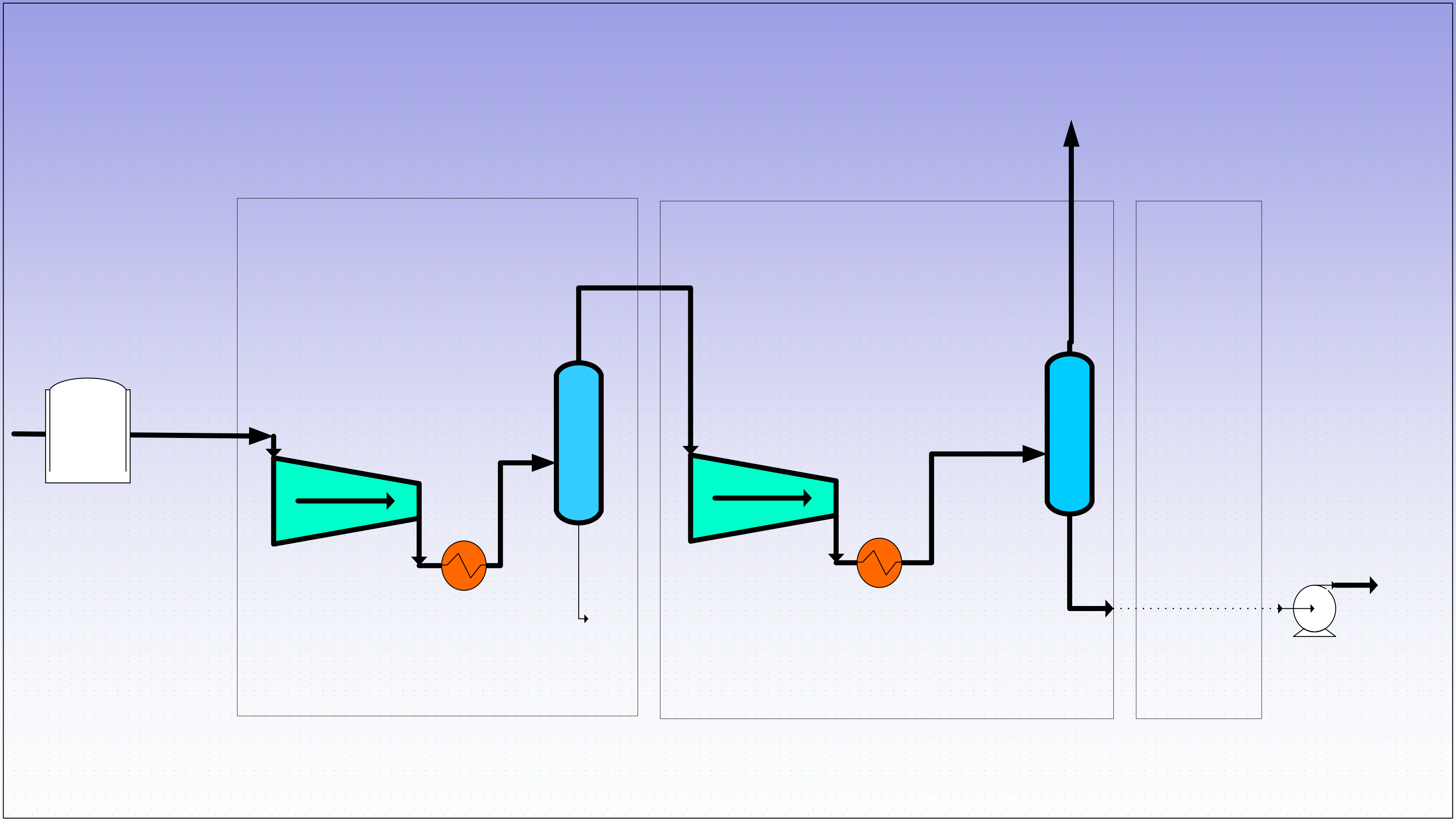
CO_2 Phase Diagram



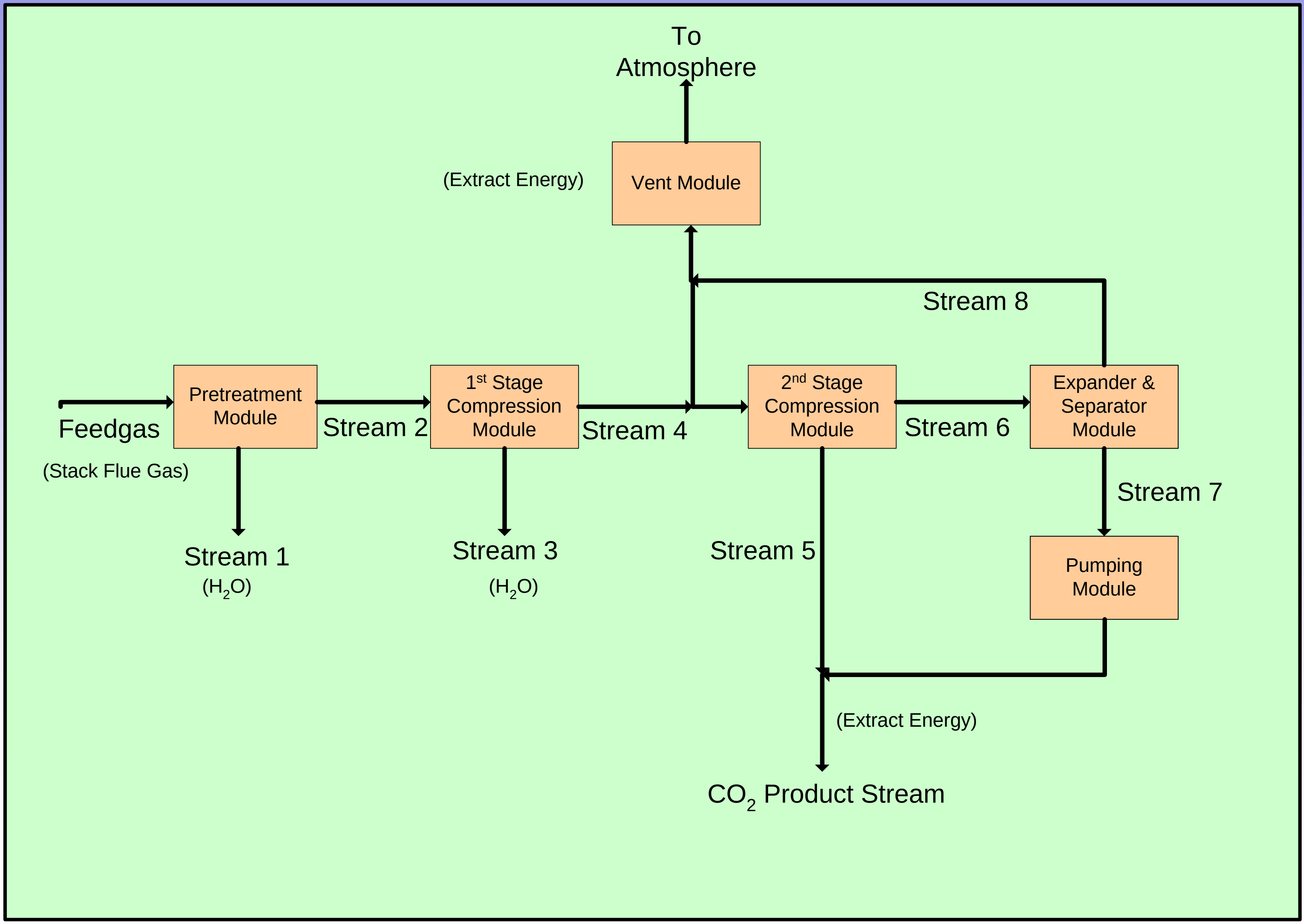


http://www.acpco2.com/index.php?lg=en&pg=2121

Conventional Multistage Compression



Autorefrigeration Separation of Carbon Dioxide (Fluor Process)



Novel CETC Process

- Proprietary process
- Some process simulation results will be presented
- Comparison between the results:
  - CETC Compression process versus Fluor Autorefrigeration/separation process

Assumptions for Simulation

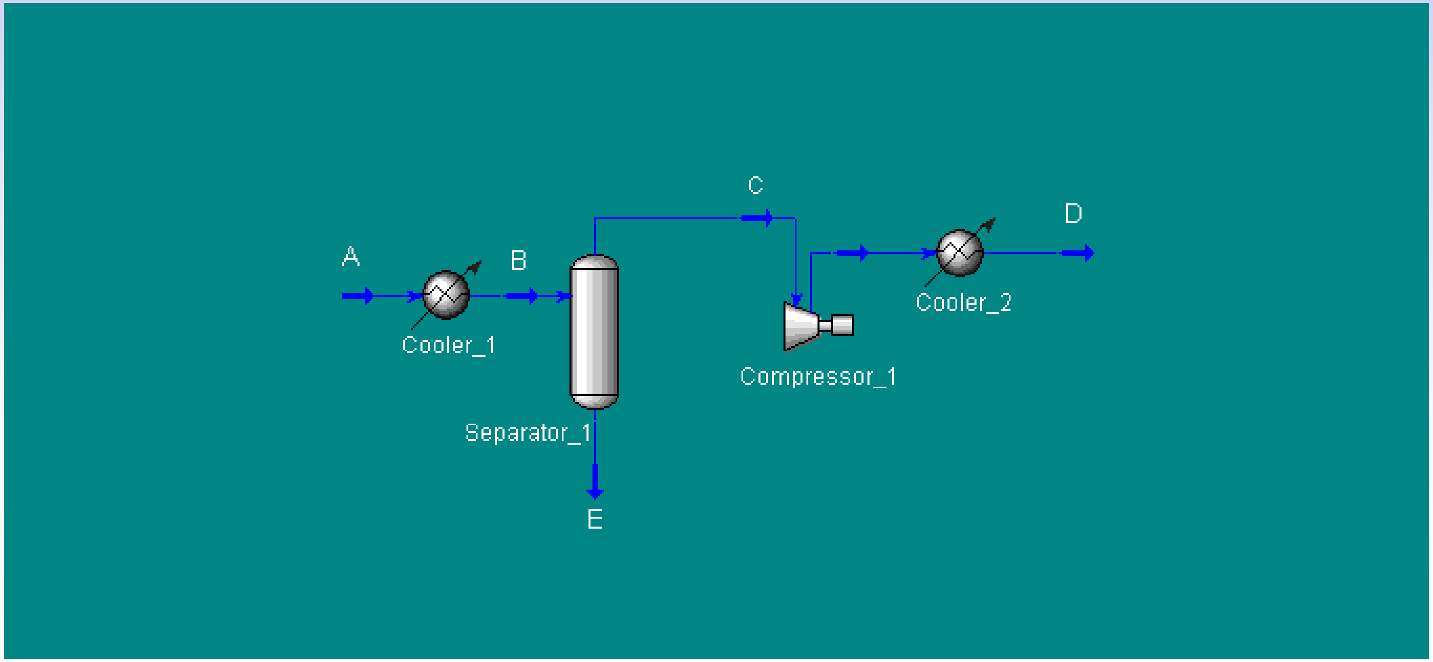
- Same baseline design conditions
- Inlet pressure and temperature
  - 1 bar, 40 ^{0}C
- Vent pressure and temperature
  - 6 bar; above dew point
- Product pressure and temperature
  - Optimum pressure is derived from the simulation at -5 ^{0}C

Feed Gas Composition

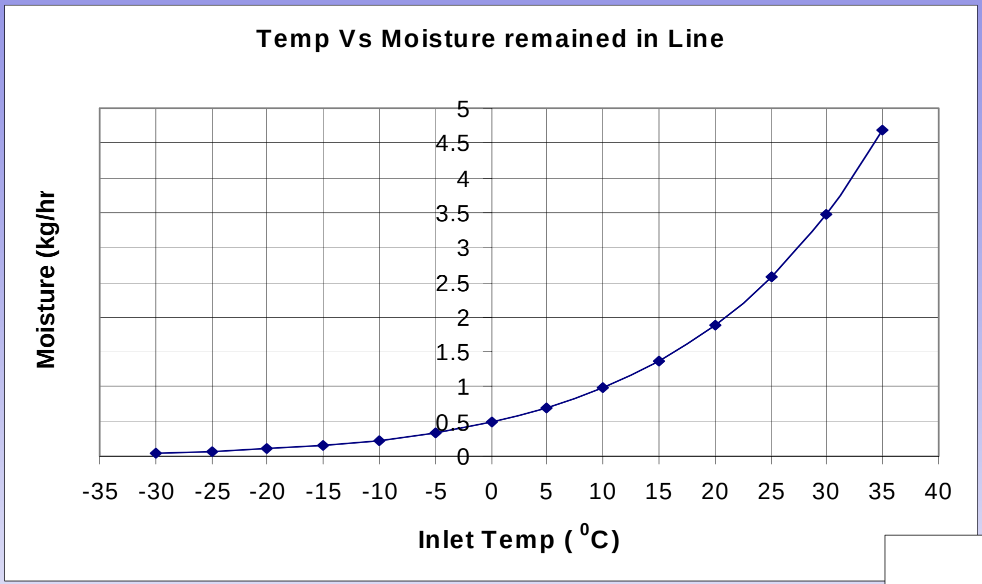
Properties	Unit	Compressor Inlet		
		Feed gas-1	Feed gas-2	Feed gas-3
Temperature	^0C	40	40	40
Pressure	bar	1	1	1
Flow Rate	kg/hr	181.0	181.0	181.0
Composition		Mole Fraction	Mole Fraction	Mole Fraction
CO_2	-	0.7443	0.800	0.8467
H_2O	-	0.0667	0.070	0.0667
O_2	-	0.0335	0.030	0.0304
N_2	-	0.1355	0.0845	0.0519
SO_2	-	0.0012	0.005	0.0014
Ar	-	0.0183	0.010	0.0024
NO	-	0.0005	0.0005	0.0005
NO_2	-	0.0001	0.0001	0.0001

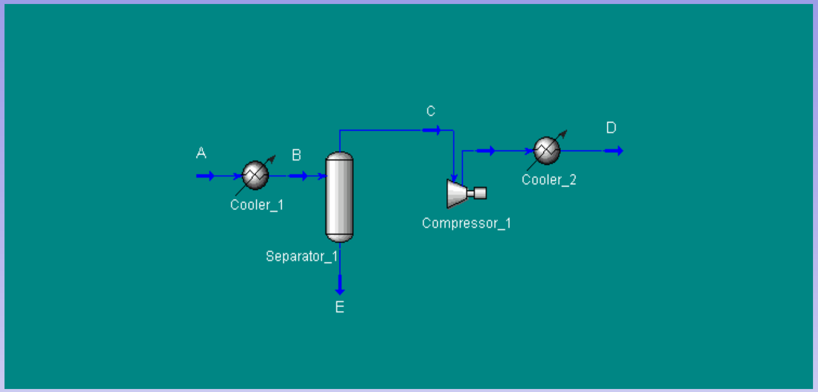
Pretreatment and Moisture Separation

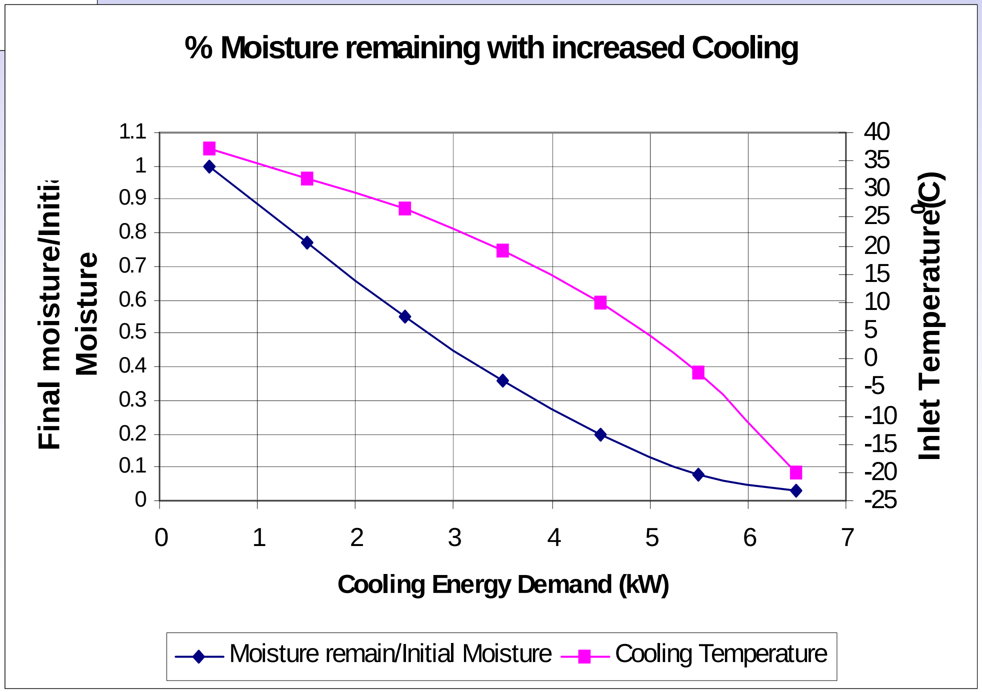
- The extent of pretreatment depends on:
  - Design considerations(ice formation, corrosion, metal properties, etc.)
  - Cost (cleaning cost, additional energy penalty, material cost, etc.)
  - Application (EOR, Storage, ECBM, etc)



Feed Gas Inlet Temperature to 1st Stage



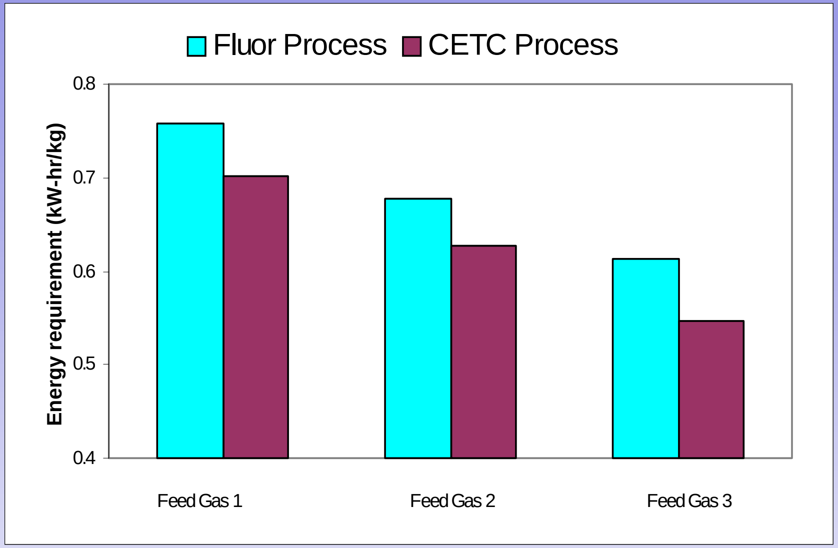


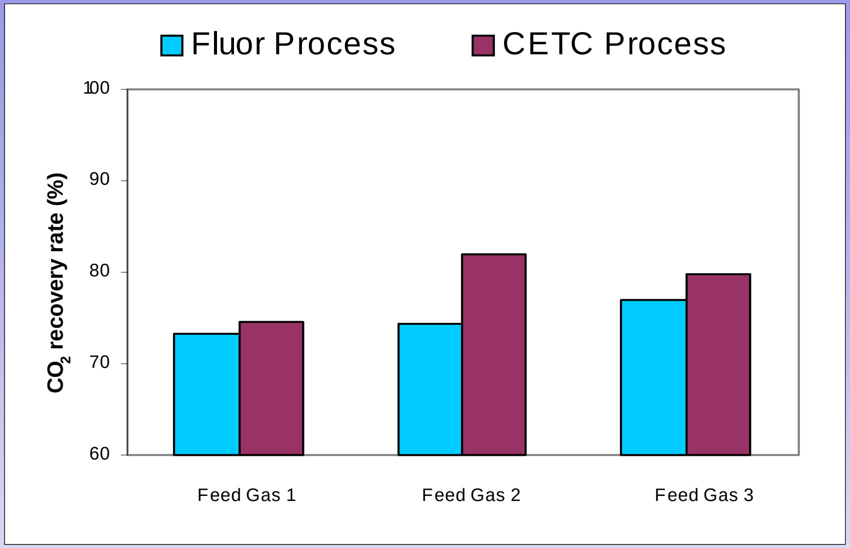


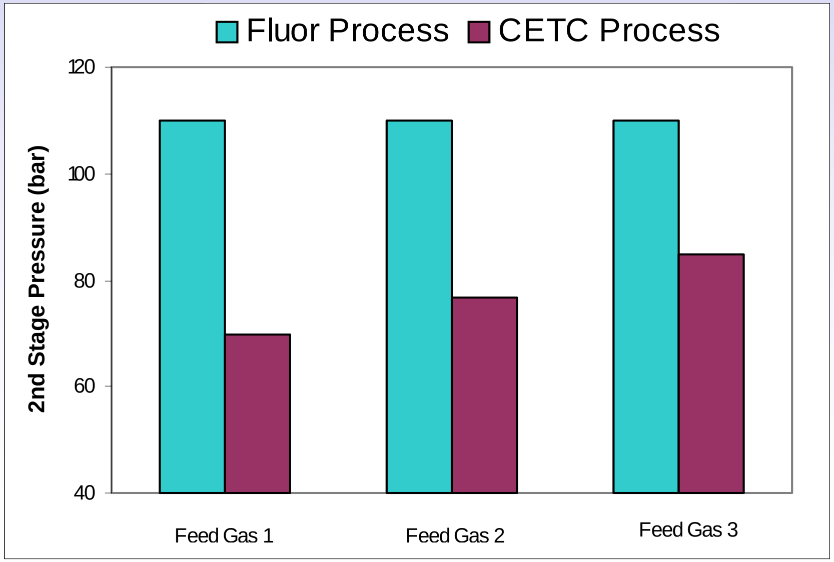
Process Modeling and Simulation

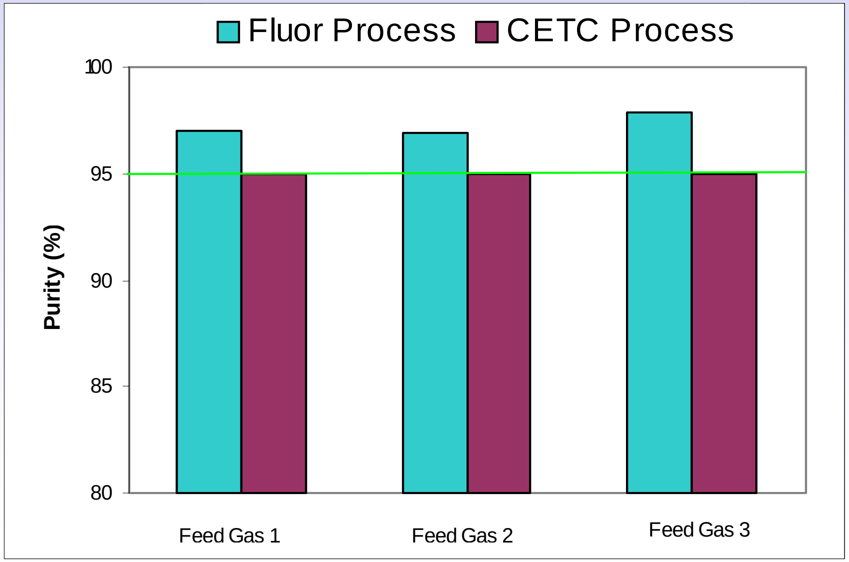
- Process Modeling
  - Both processes were modeled in HYSYS
  - Same initial feed gas characteristics and final product conditions.
  - Product CO_2 purity equal or above 95%
- Processes Optimization
  - CO2 recovery
  - Energy requirement
  - Stage pressure and recycle ratio

Comparison of Results

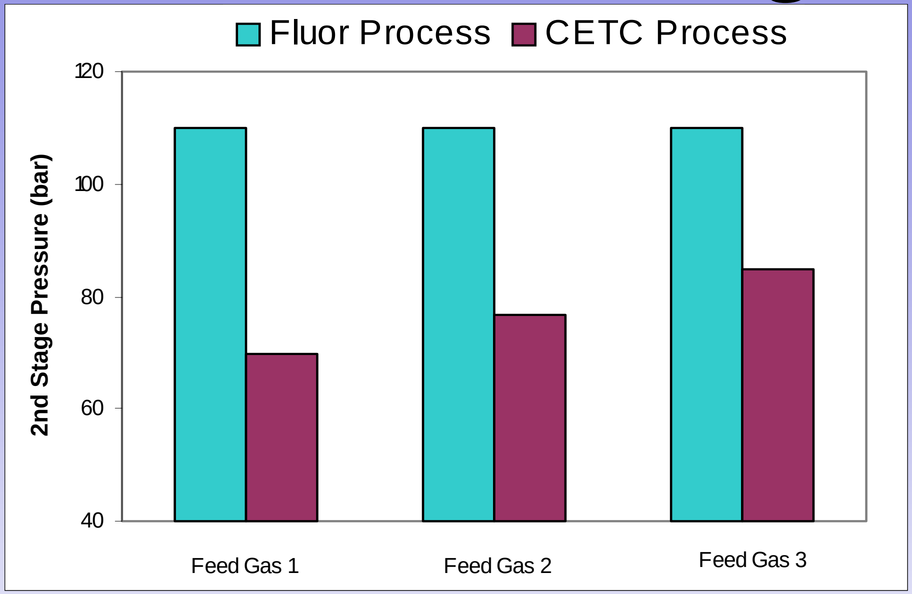


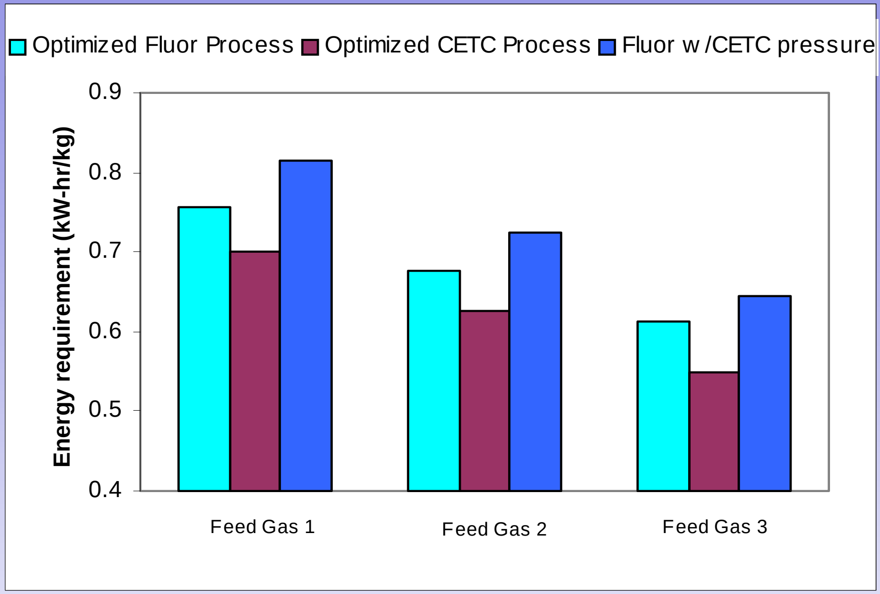


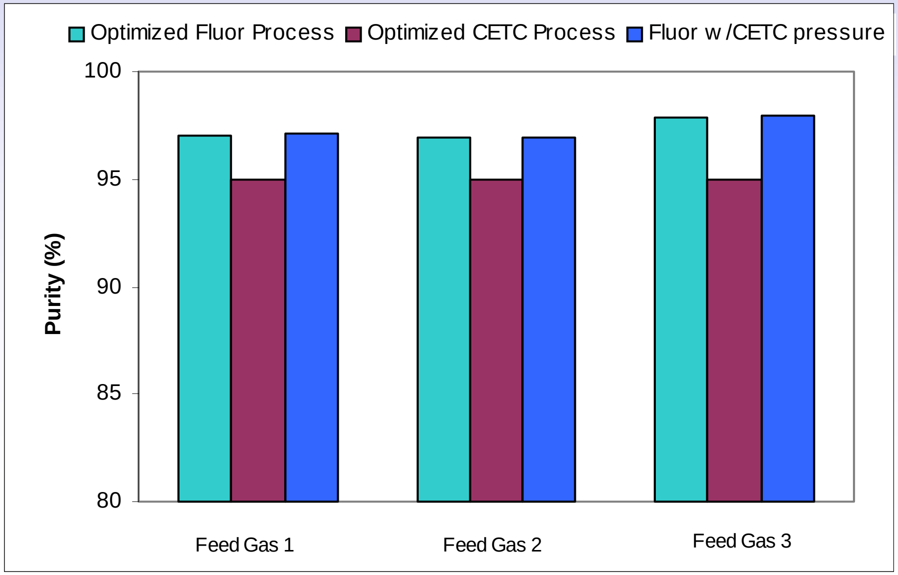


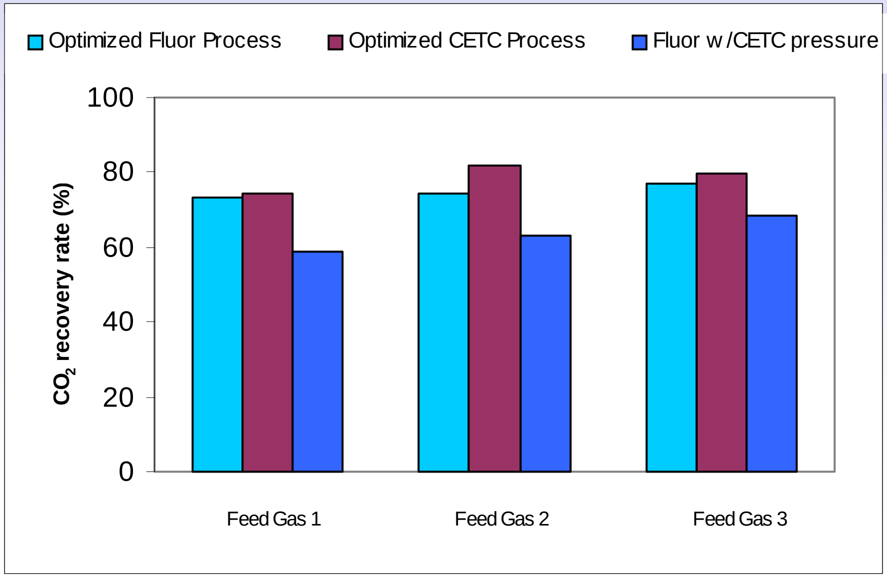


Fluor Process at Different Optimized 2nd Stage Pressure

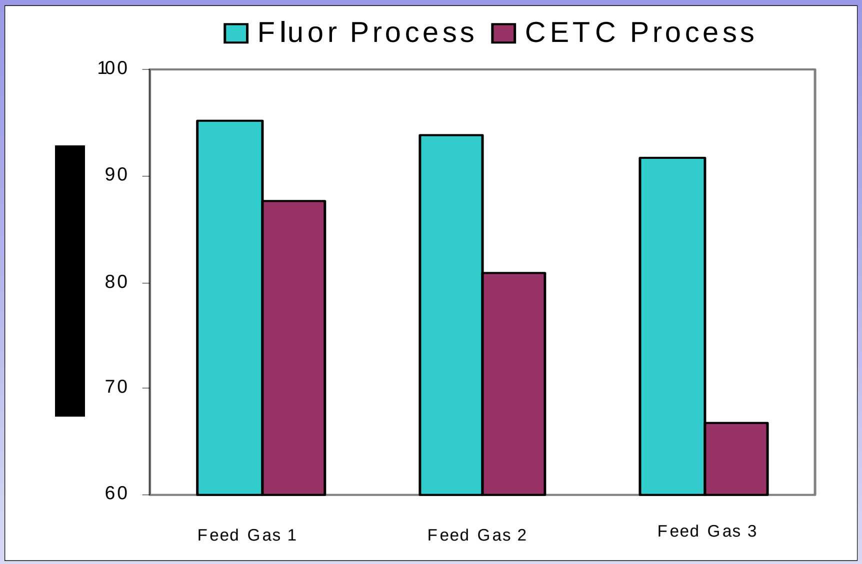


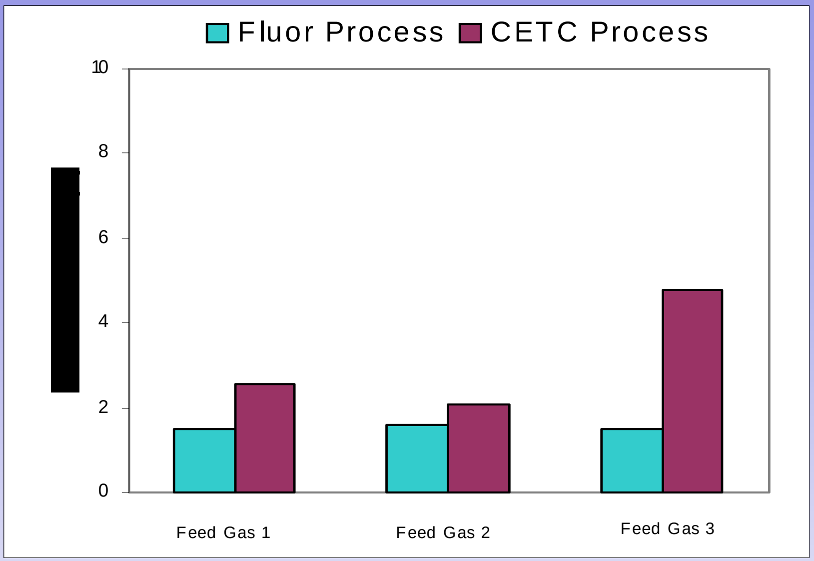


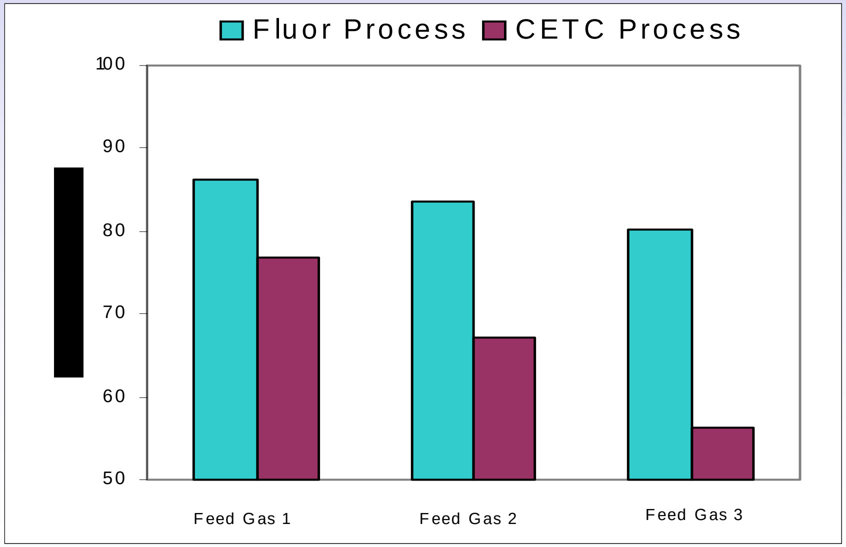


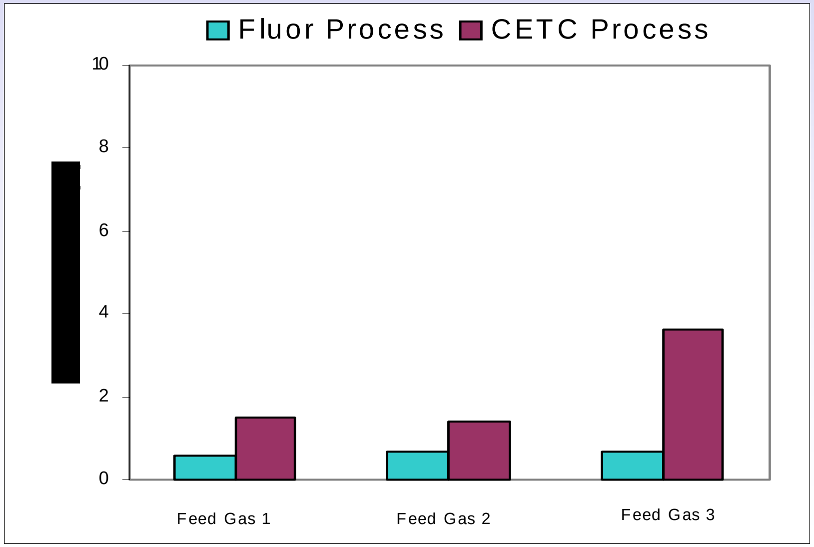


Impurities Distribution in Vent Stream

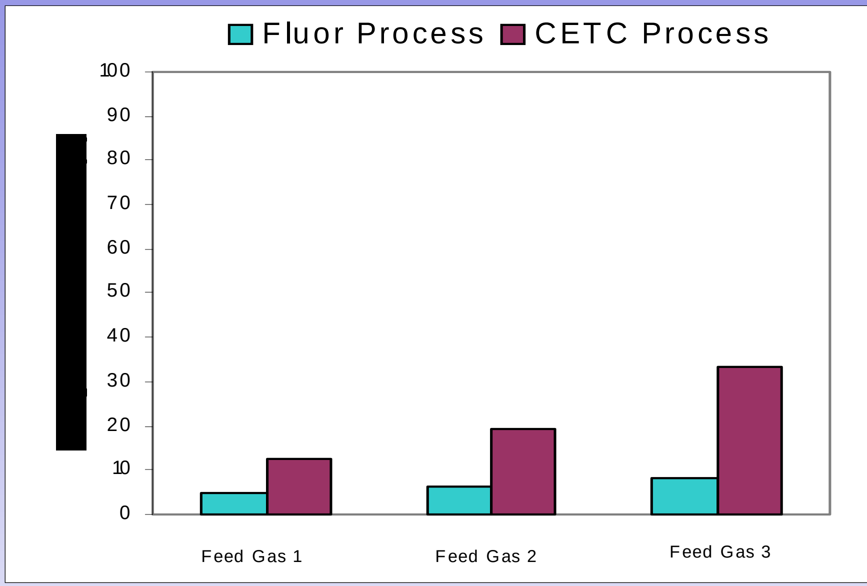


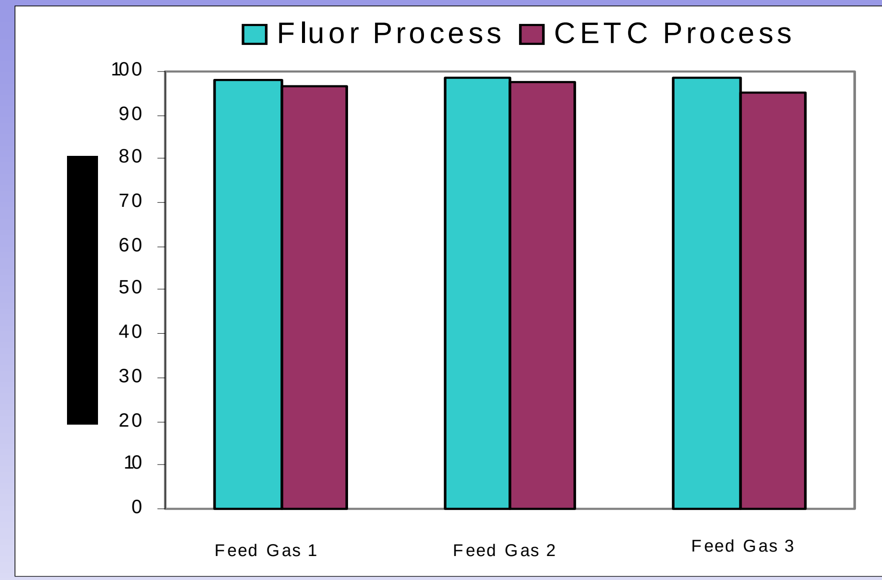


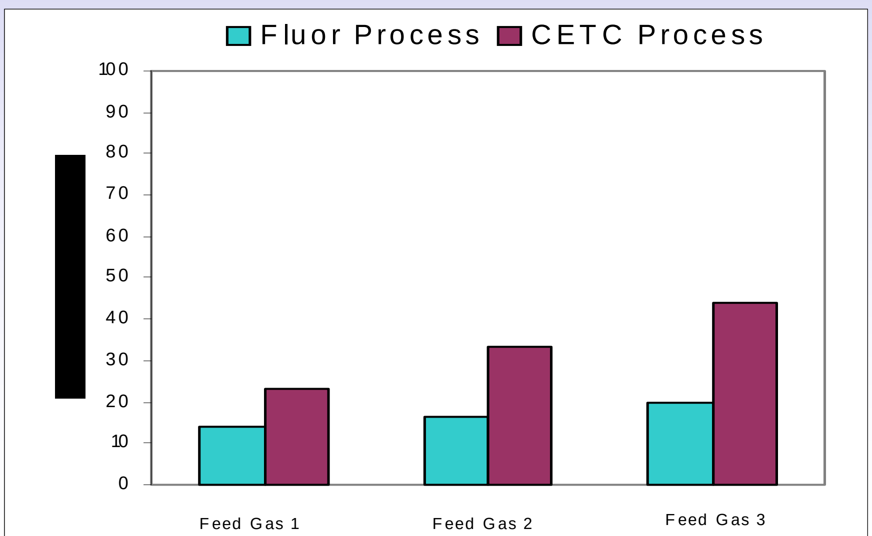


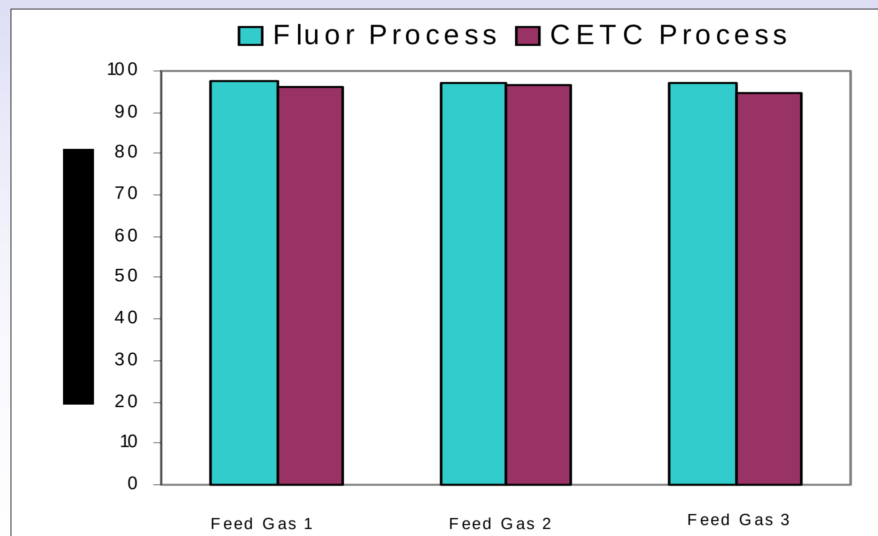


Impurities Distribution in Product Stream









Conclusions

- Many factors impact the design of a CO_2 compression unit for oxy-fuel combustion
- The impact of impurities in the process design is an open area for research
- The once-through CO_2 compression process is well established and easy to implement.
- Autorefrigeration process performance is superior to the once-through compression process
- Process simulation results shows that CETC process offers significant improvement over Autorefrigeration process.
  - Improved energy efficiency at product purity above 95%
  - Lower liquid product pressure before the pumping module
  - Higher recovery rates