Enerflex

GPA MIDSTREAM ASSOCIATION

Optimizing Gas Processing in the Permian Basin

Choosing between TEG with molecular sieve (MS) polishing or fully saturated MS dehydration

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Problem Statement

- Compare cost and operational concerns for dehydration upstream of a cryogenic plant
- TEG + **Unsat**urated versus **Sat**urated Sieve
  - *250 MMscfd and 350 MMscfd*
- Assumptions:
  - *1,100 psi MAWP, 0.0625” CA CS*

Feed	
Temperature [F]	120
Pressure [psig]	848
Flow [MMscfd]	250 & 350
	Mole Frac
Nitrogen	0.039
Methane	0.705
Ethane	0.120
Propane	0.084
i-Butane	0.007
n-Butane	0.026
Pentane+	0.015
Water Content [lb/MMscfd]	112 (Saturated)

TEG Design and Sizing

	250 MMscfd	350 MMscfd
Outlet Content [lb/MMscfd]	6.32	6.33
TEG GPM	54	75
TEG Purity, weight%	99.08%	
TEG Contactor	7' ID X 30'S/S	8' ID X 30'S/S

- 3-gallon TEG / # H_2O assumed for circulation rate, with 7 lb / MMscfd targeted
- If BTEX is present, outlet content will slip to 8.27 lb / MMscfd with the purity reduced to 98.74%
- If sparged stripping gas (2 SCF / Gal TEG) is added, purities 99.05% to 99.34%
  - Water content outlet 4.77 #/MMscfd to 6.46 #/MMscfd

Sieve Design and Sizing

	250 MMscfd / 350 MMscfd	
	Unsat	Sat
Water Content of Fresh Feed [lb/MMscfd]	15	112
Adsorption Time per cycle [hour]	18	12
Regen Gas Rate per bed [MMscfd]	13 / 17.5	28.8 / 42
Sieve Vessel ID (3 required) [feet]	8.5 /10	9 /10.5
Actual S/S Height [feet]	16	30 /32
Regen Gas Heater Duty [MMBtu/hour]	4.99 / 7.19	21.78 / 31.27

*Enerflex developed a hybridized tool using the GPSA 14th Edition Method utilizing 4A sieve, assuming 14.5% lb water / lb sieve with performance degradation

- Short adsorption times = minimum Sat CAPEX and OPEX “Best Engineering Judgement”
- Unsat: minimum required regen flows due to minimum pressure drop requirements

Equipment CAPEX and Vessels

	250 MMscfd / 350 MMscfd	
	TEG + Unsat Sieve	Sat Sieve
Cycle Times [hour]	18	12
Sieve Adsorbers [QTY 3]	8.5’ / 10’ID X 16'S/S	9’ / 10.5’ID X 30’S/S X 32’S/S
TEG Contactor	7’ / 8’ID X 30'S/S	NA
Weight Vessels [1,000 lbs]	360 / 497	484 / 736

- Weight Matters: **TEG + unsat is ~1 million US$ cheaper**
  - Excludes total installed cost (TIC) and fill volumes
- Cycle Times: 12 versus 18 hours on sat design
  - 18 Hours : Unsat +5% (minimal impact), Sat +35% (mid to big impact)
- Water Matters
  - Hot day (125°F)
  - +20% glycol circulation (minimal cost impact), +10% to total sieve design (big impact)

Initial Fills, Emissions, and OPEX

- Assumptions:
  - Yearly glycol replacement ($12/gallon), 3-year sieve changeout ($2.75/lb), 7¢/kWh, $2.75/MMBtu fuel
- Fills: Sat is $0.3 million US$ more expensive (initial)
  - $2.1 million to $3.5 million US$ over 20 years *(note replacement times TEG vs. Sieve differ)*
    - Unsat beds could last longer due to 12-hour versus 18-hour cycle time
    - If 3-year glycol and 5-year sieve changeout, reduced to $1.3 million to $2 million US$
- Emissions:

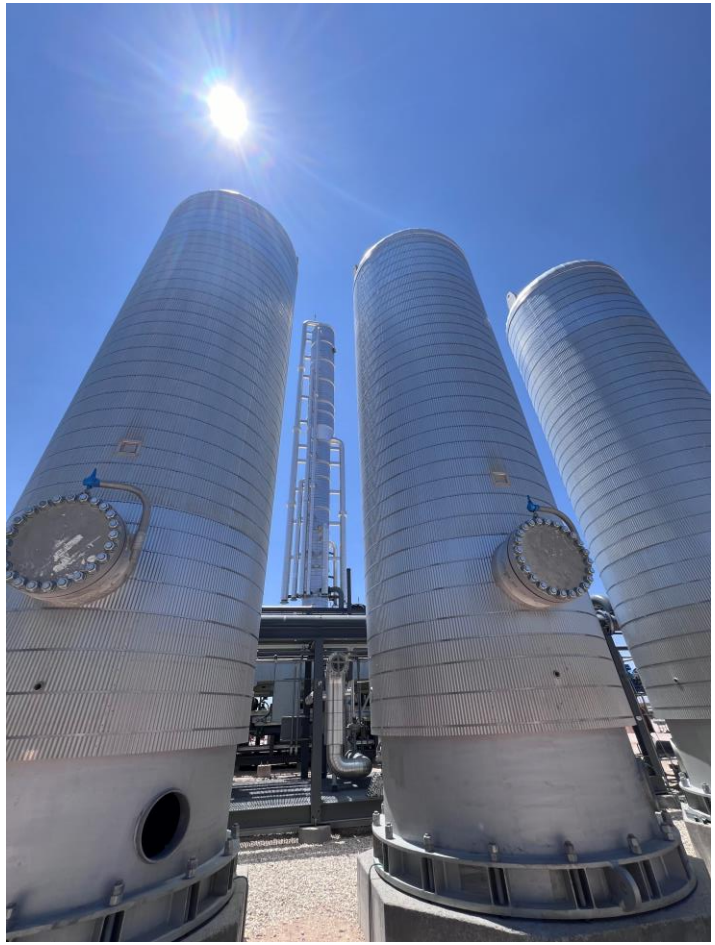
	250 MMscfd / 350 MMscfd	
	TEG + Unsat	Sat
Corrected Total Duty [MMBtu/hour]	6.20 / 8.86	13.07 /18.76
Yearly emissions [CO2+CO tons/year]	4,470 / 6,380	9,421 / 13,527

Note Point emissions are higher for a TEG + Unsat

- OPEX: $0.15 million to $0.25 million US$ / Year
  - $3 million to $5 million US$ over 20 years

Total Installed Cost, Plot, and Shipping

- Total Installed = ~Neutral costs
  - Assumption: 2x Equipment = TIC cost assumption with inefficiency
  - 2 plants in series is inefficient and more costly
    - *Eroding the Equipment CAPEX cost advantage*
- Operating cost favors TEG, if upsets kept in check
- Plot +30% with TEG system, but small
  - If amine present, somewhat inconsequential
- Crawlers, large cranes, and robust shipping prevalent with Sat
  - Shipping $/ sieve vessel +60% at 250 MMscfd
  - 3x higher for 350 MMscfd



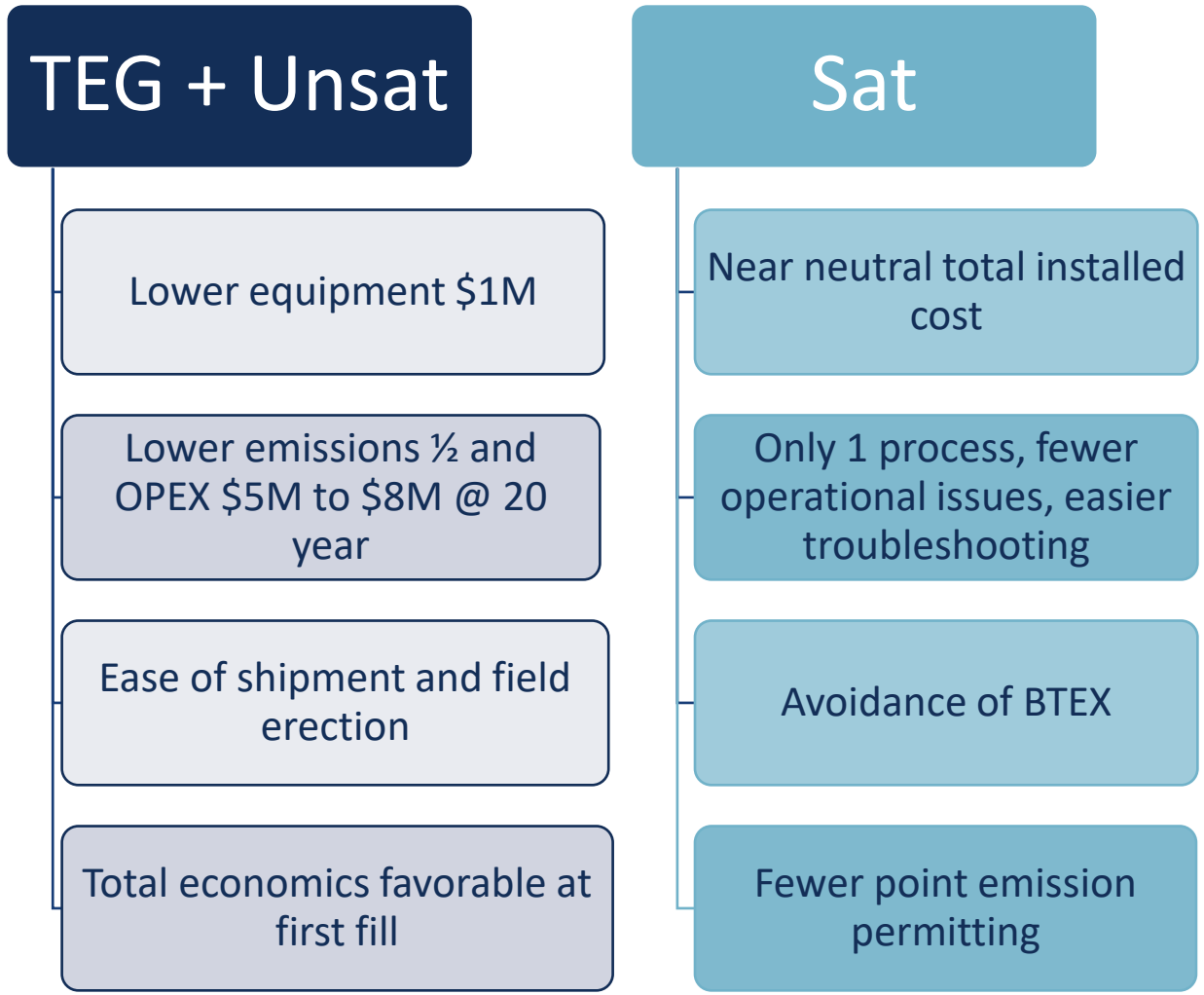
Operational Considerations

- Unsat: Ramp up easier in Unsat
  - High regen rate + Low adsorber volume (excess standby)
  - This minimizes refluxing concerns
- Foaming events, specifically glycol, are detrimental to sieve (Block & Bake), but amine may only be hindering
  - Glycol = lower volume event? & easier for coalescing to handle
- BTEX is not an issue for Sat, but may show up in amine
  - Poses environmental, engineering, operations, and emissions issues
- Smaller Unsat beds may changeout more quickly

Final Conclusions

- Company preference will always prevail, however:

- 350 MMscfd versus 250 MMscfd:
  - Cost advantages, both CAPEX and OPEX are widened with larger plant size
    - Big Plants justify Unsat
      - If permitting and operations can handle both systems



Questions?