ACID GAS ENRICHMENT – NEW WRINKLES ON AN OLD PROCESS

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Agenda

- Introduction & Background
- Case Study Design Basis & Definition of Cases
- Process Comparison
- CapEx, OpEx & Lifecycle Cost Comparison
- Summary & Conclusions
- Next Steps

Introduction

Lean acid gas results in the following SRU complications

- Cool thermal reactor temperature and flame instability
- Poor destruction of impurities - hydrocarbon (BTX) and NH_3

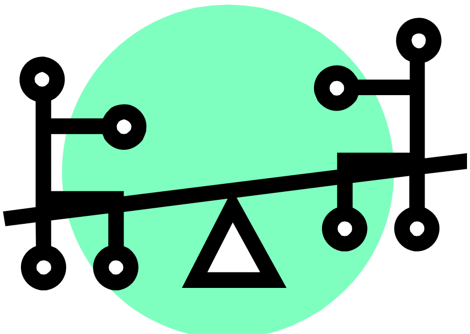
FUEL GAS CO-FIRING

- Fuel consumption OpEx (RF, RGG, Incin.)
- Increases size of SRU/TGTU
- Possible catalyst damage – sooting/O_2 fire

ACID GAS ENRICHMENT

- AGE amine circulation OpEx
- More equipment/operating complexity
- Reduces size of SRU/TGTU
- Improved acid gas quality
  – higher H_2S% & reduced impurities

Process Parameters Impacting Selectivity



Not Selective

- **Higher P**
- **Higher T (μ)**
- Over-circulated

Selective

- Lower P
- Lower T
- Optimized circulation
- Minimal H_2S lean loading (if pinched)

Mass Transfer Rates Control Selectivity

- Pickup Rate $\propto$ k A (ΔConcentration)

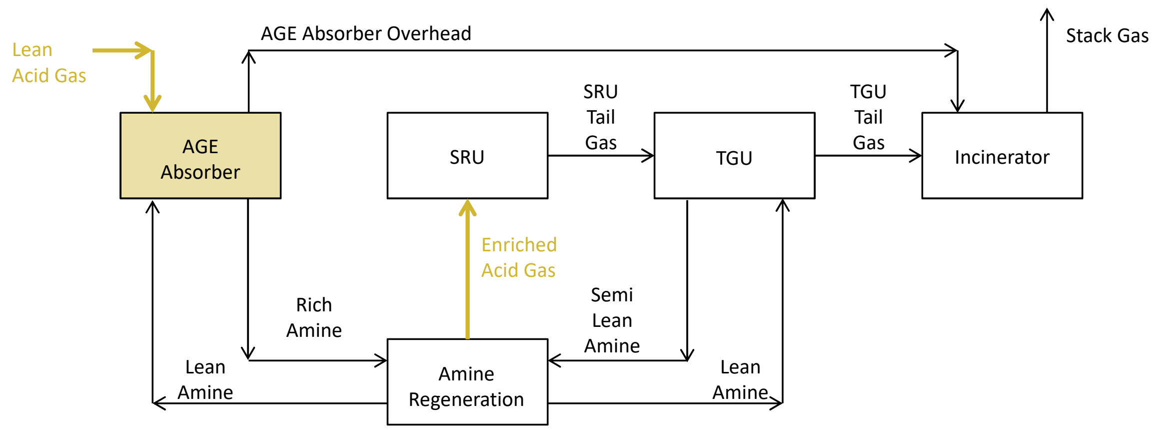
  Mass Transfer Coefficient (k) · Area (A) · Driving force (ΔConcentration)

- Extent of disequilibrium (NOT at Equilibrium) drives mass transfer
- H_2S often gas film controlled
- CO_2 often liquid film controlled
- More area → More mass transfer
  - Good for H_2S, not so good for CO_2

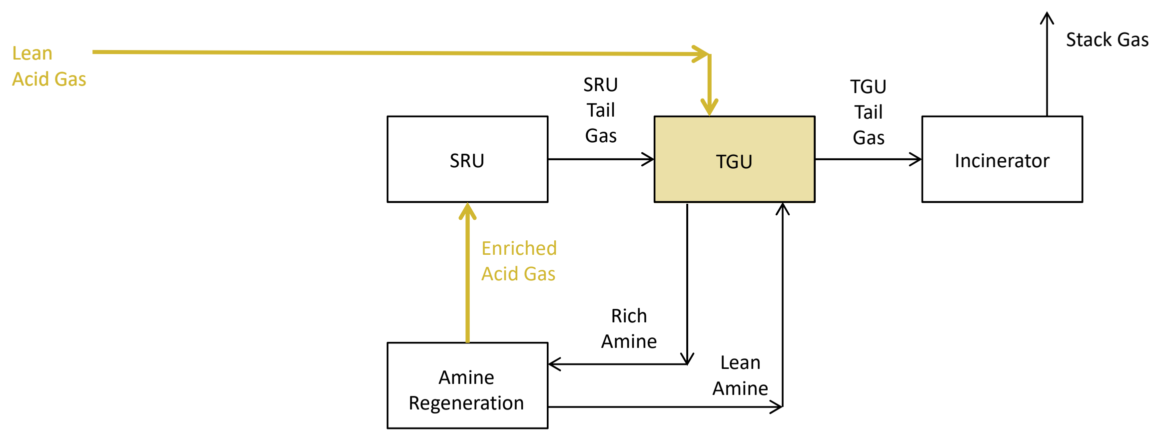
Mass Transfer Rate

- Area & mass transfer coefficients depend on...
  - Gas & liquid loads (rates)
  - Mass transfer internals type
  - Hydraulics (specific tower internals)
  - Physical properties (density, viscosity, diffusion)
    - f (T, P, solvent concentration and type)
- ProTreat® software used for this study accounts for all these factors

Typical Acid Gas Enrichment BFD



The New Wrinkle…



Case Study Design Basis

ACID GAS FEED

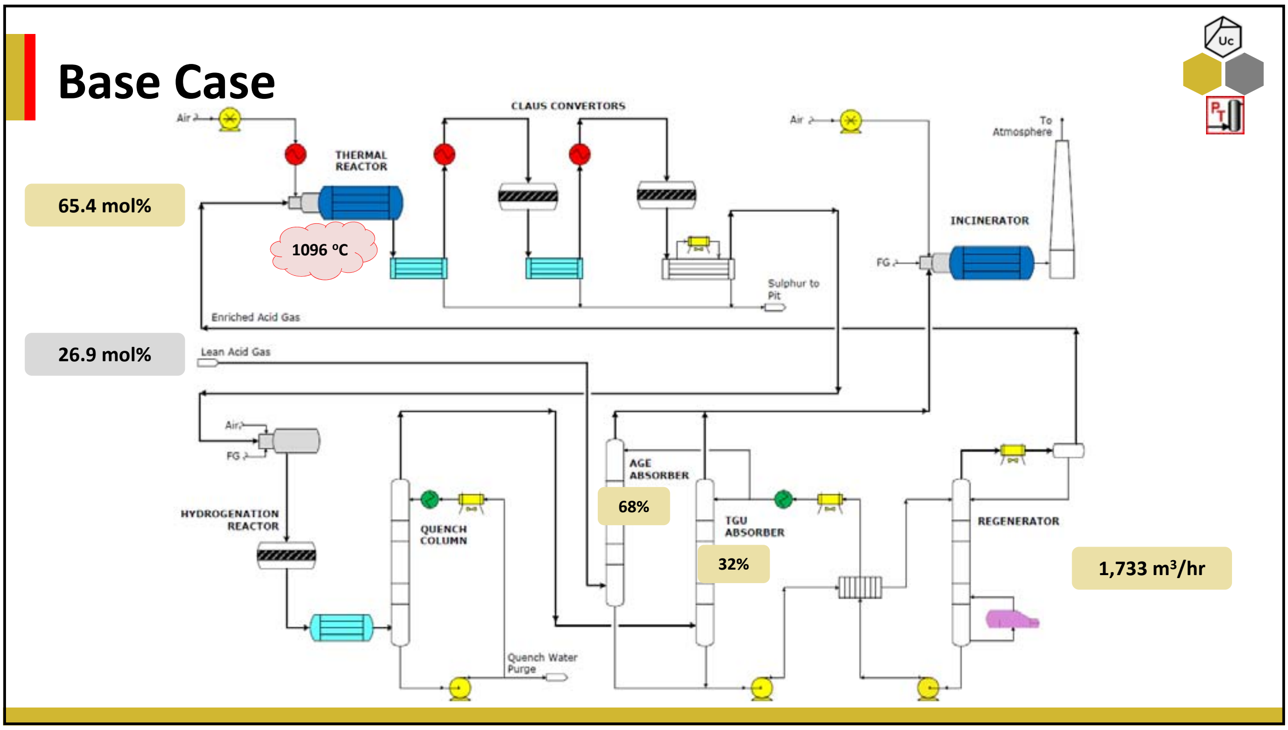
Component	Mole %
Water	10.48
Hydrogen Sulfide	**26.86**
Carbon Dioxide	62.18
C1	0.27
C2	0.10
C3	0.07
C4	0.04
C5	0.01
Total Flow	4,838 kmol/h

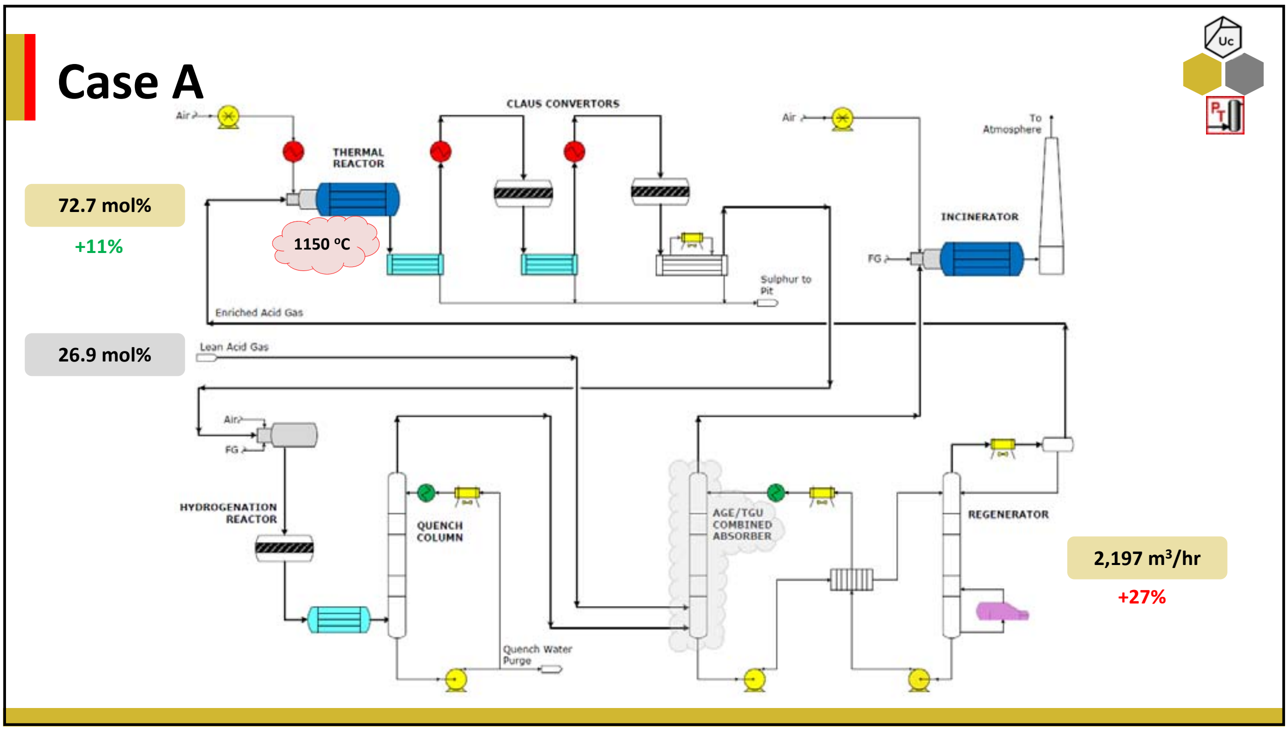
- 1,000 MTPD
- AG Pressure: ~0.9 barg
- AG Temperature: 60°C
- 40 wt% MDEA AGE/TGTU
- 99.9% SRE
- Air cooling to 60ºC
- Propane trim cooling

Cases

CASE	AGE ABSORBER	LEAN AG FEED TO:	ENRICHED AG FEED TO:	# OF CLAUS STAGES
Base	Standalone	AGE Absorber	SRU	2
A	Combined AGE/TGU	AGE/TGU Absorber	SRU	2
B*	Combined AGE/TGU	Quench Column	SRU + Quench	2
C	Combined AGE/TGU	AGE/TGU Absorber	SRU	1
D	Combined AGE/TGU	Quench Column	SRU	1

*Basis of **HIGHSULF™ Process**
Patent# 5,556,606, expired


Base Case
65.4 mol%
26.9 mol%
1096 ºC
Air
THERMAL REACTOR
CLAUS CONVERTORS
Sulphur to Pit
Enriched Acid Gas
Lean Acid Gas
INCINERATOR
To Atmosphere
FG
HYDROGENATION REACTOR
QUENCH COLUMN
Quench Water Purge
AGE ABSORBER
68%
TGU ABSORBER
32%
REGENERATOR
1,733 m³/hr

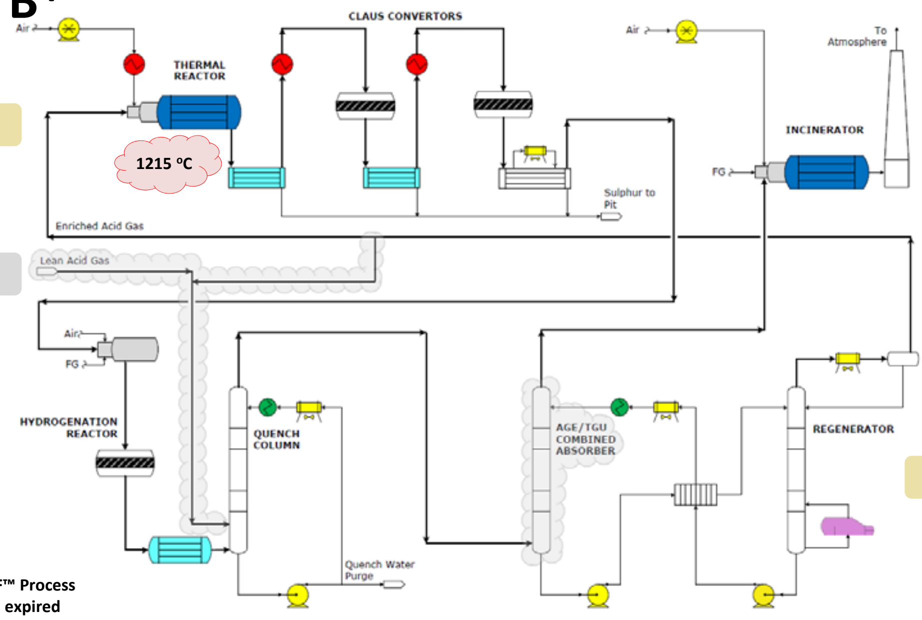

Case A
72.7 mol%
+11%
26.9 mol%
1150 ºC
Air
THERMAL REACTOR
CLAUS CONVERTORS
Sulphur to Pit
Enriched Acid Gas
Lean Acid Gas
INCINERATOR
To Atmosphere
FG
HYDROGENATION REACTOR
QUENCH COLUMN
Quench Water Purge
AGE/TGU COMBINED ABSORBER
REGENERATOR
2,197 m³/hr
+27%

Case B*

80.8 mol%

+24%

26.9 mol%



2,664 m³/hr

+54%

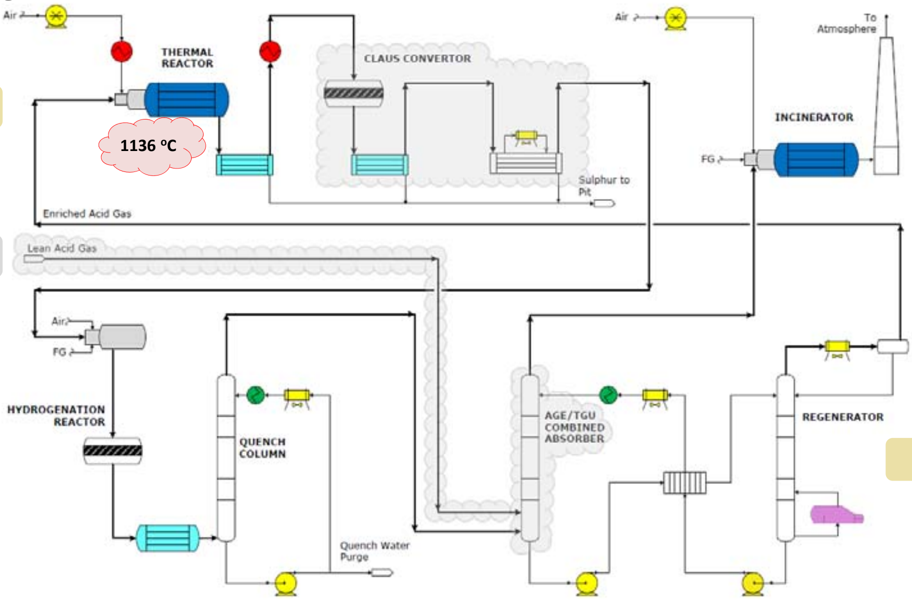
*Basis of **HIGHSULF™ Process**
Patent# 5,556,606, expired

Case C

73.3 mol%

+12%

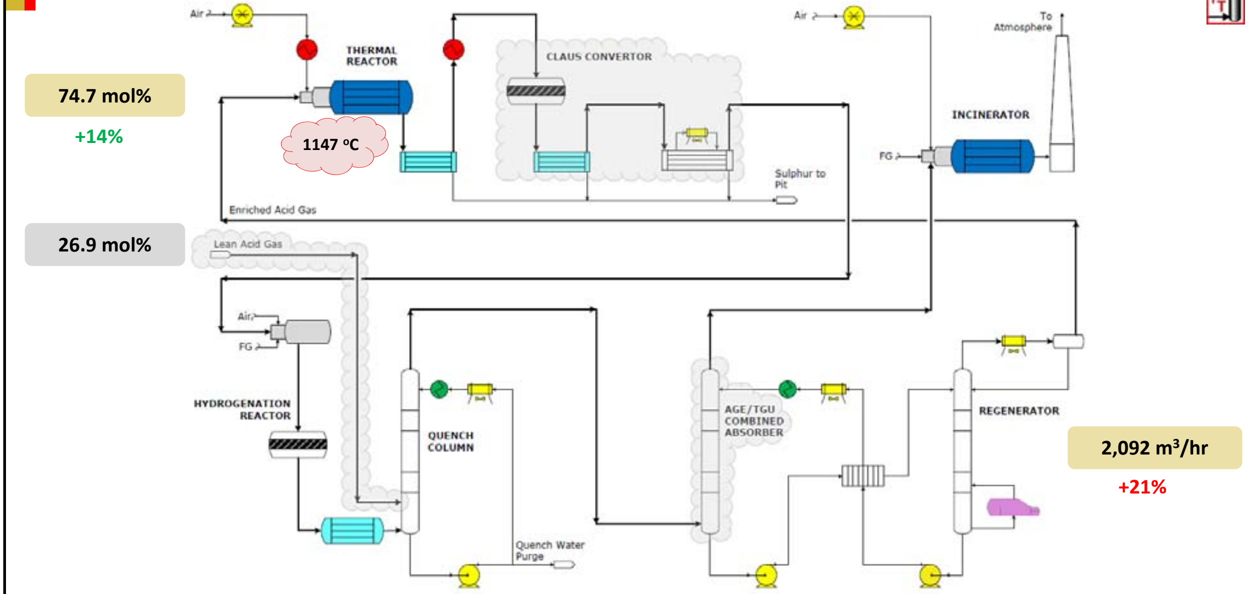
26.9 mol%



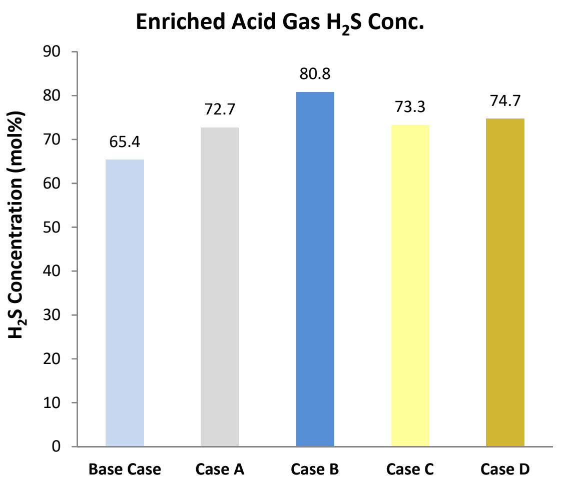
2,221 m³/hr

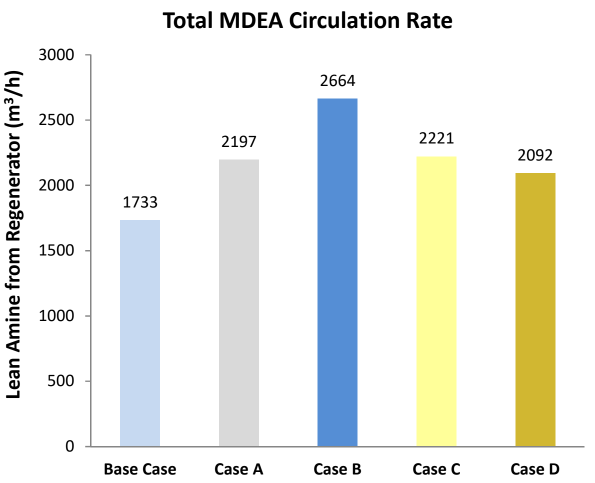
+28%

Case D

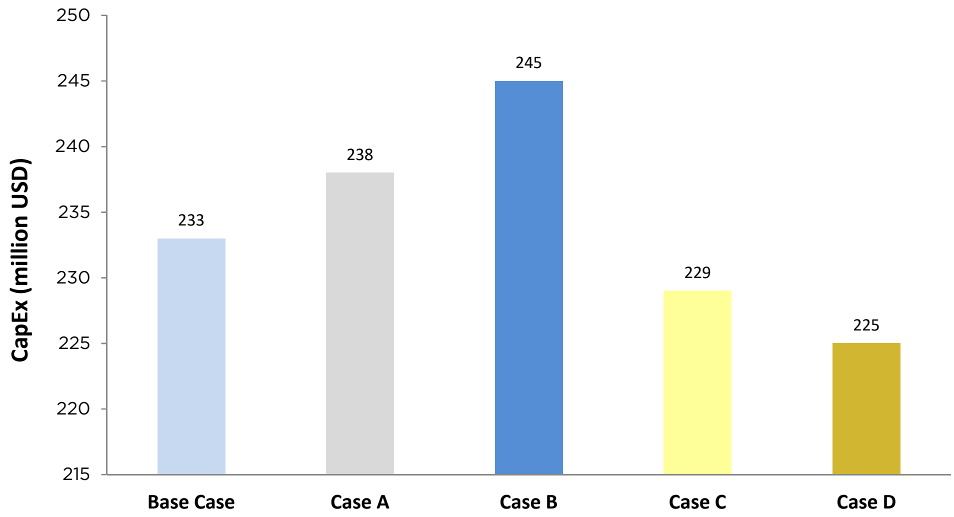


Process Comparison



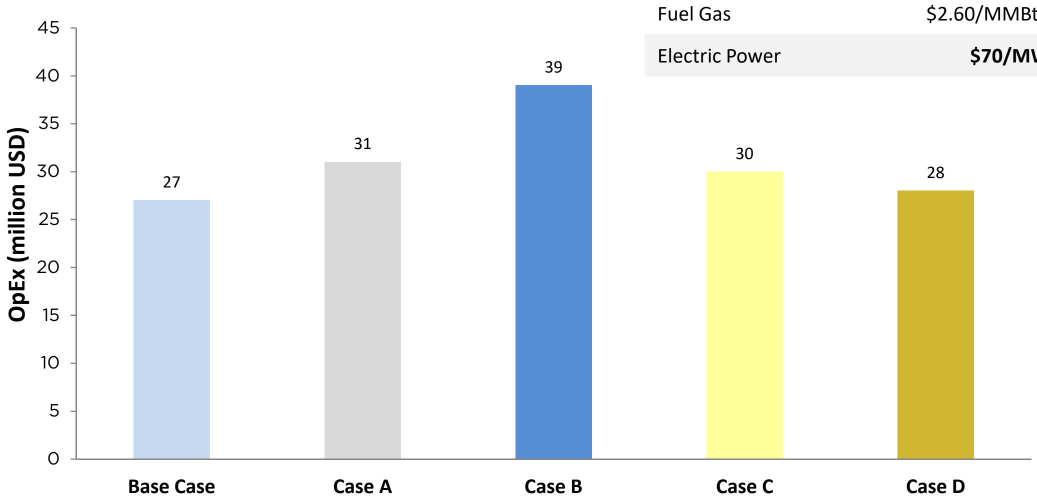


CapEx Comparison



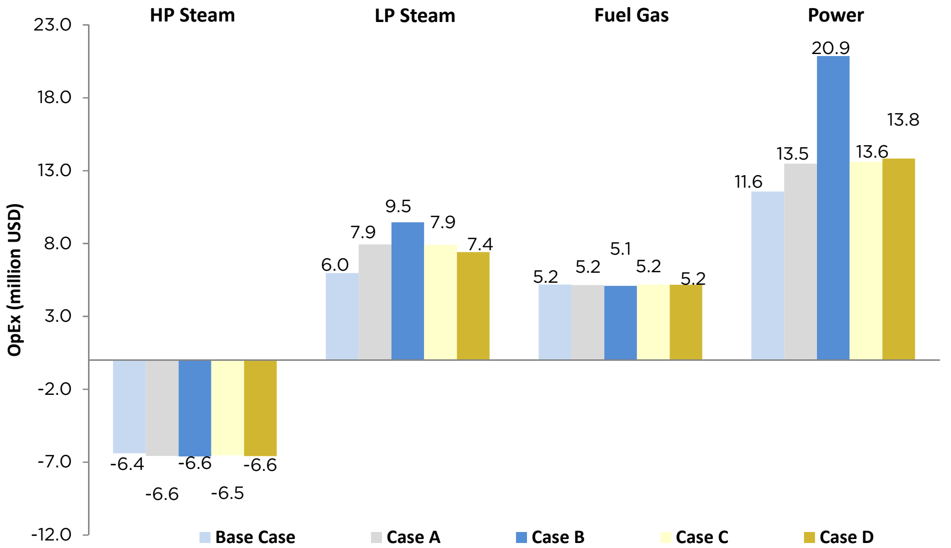
OpEx Comparison

Utility	Price
HP Steam	$5.80/ton
LP Steam	$3.60/ton
Fuel Gas	$2.60/MMBtu
Electric Power	**$70/MW**

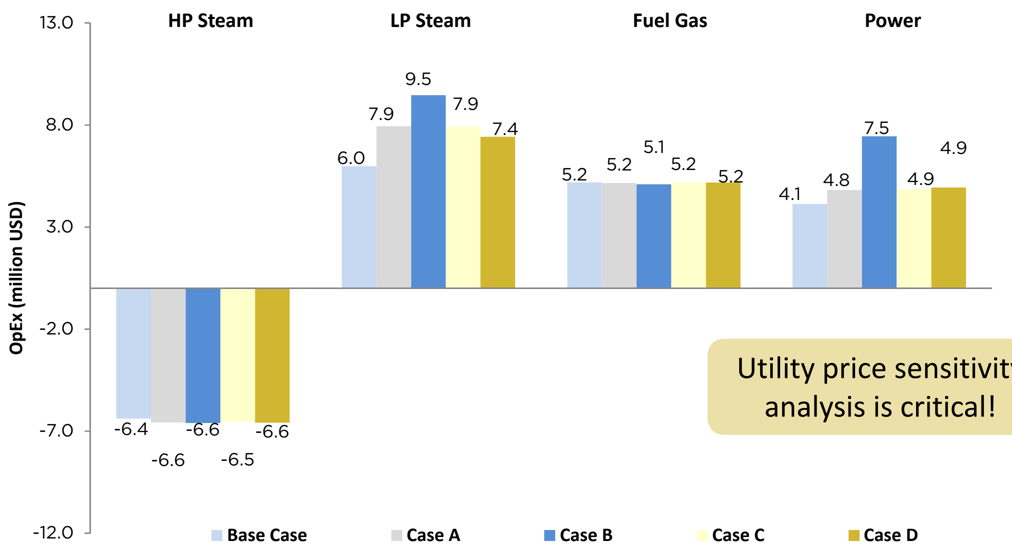


Note: Sulphur revenues not included

OpEx Comparison by Utility

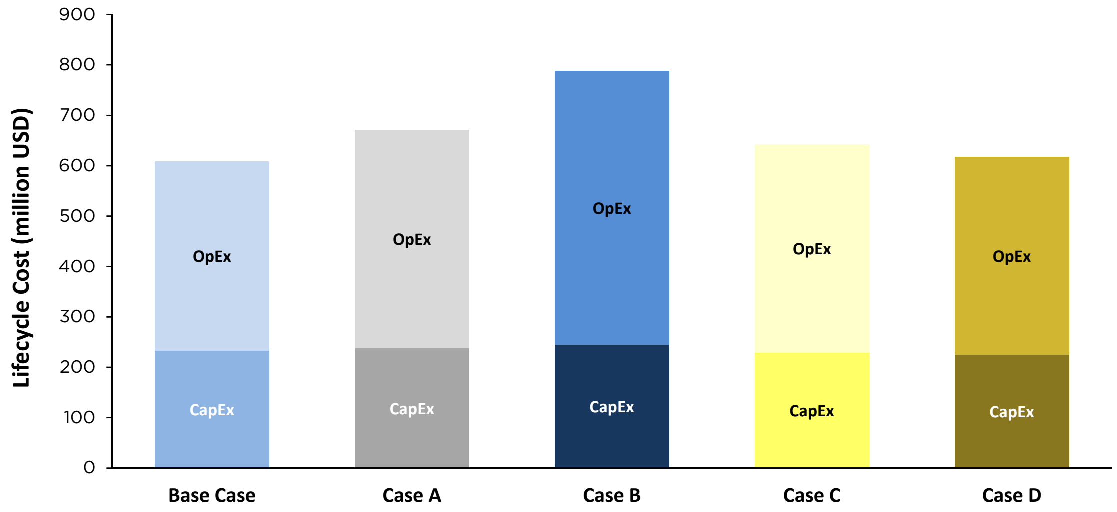


Alternate OpEx Comparison by Utility ($25/MW)



Utility price sensitivity analysis is critical!

Lifecycle Cost Comparison



Note: Sulphur revenues not included

Summary & Conclusions

- Acid gas enrichment improves acid gas quality & SRU operation
- Routing lean acid gas to **TGU absorber**
  - Improves enrichment
  - But increases CapEx & OpEx
- Routing lean acid gas to **quench column**
  - Improves enrichment even further
  - But also increases CapEx & OpEx further

Elimination of a Claus stage alleviates cost impact….
but may not be recommended (TGU bypass operation)

Next Steps

- Consider leaner acid gas to understand full range of benefits
- Other solvents?
- Off-ratio tail gas (H_2S rich) selectivity benefits (SINI HCR™)
- Compare AGE cases to fuel gas firing
- Assessment in cooler climate without refrigeration requirement
- **Utility price** sensitivity analysis
- Formal paper