Comparison of FEED Results from Mustang Station and Panda Power

DE-FE0031844 and DE-FE0031848

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"Mustang FEED" DE-FE0031844, University of Texas

Cost estimate for PZAS, second-generation amine scrubbing process

Final report submitted July 2022: (not yet available online)

"Panda FEED" DE-FE0031848, Bechtel

Cost estimate for a generic design using low-cost solvent (MEA)

Final report submitted March 2022: https://doi.org/10.2172/1836563

Objective of this comparison

Both use amine scrubbing CO_2 capture at NGCCs in Texas

Results were published in extensive detail

Validate cost estimates, draw insights to reduce capital cost

Outline

- Key design decisions
- Direct field cost adjustment
- Breakdown of costs by process area
- Scaling Mustang cost to same basis as Panda FEED
- Comparison of absorber design alternatives

Panda handles 19% less flue gas, captures 31% less CO_2

	Mustang	Panda
NGCC flue gas flow [t/hr]	2880	3700
Flue gas feed to capture unit [t/hr]	3160 (NGCC + boiler)	2530
Captured CO_2 stream [t/hr]	200	130
Design Capture [%]	90	85

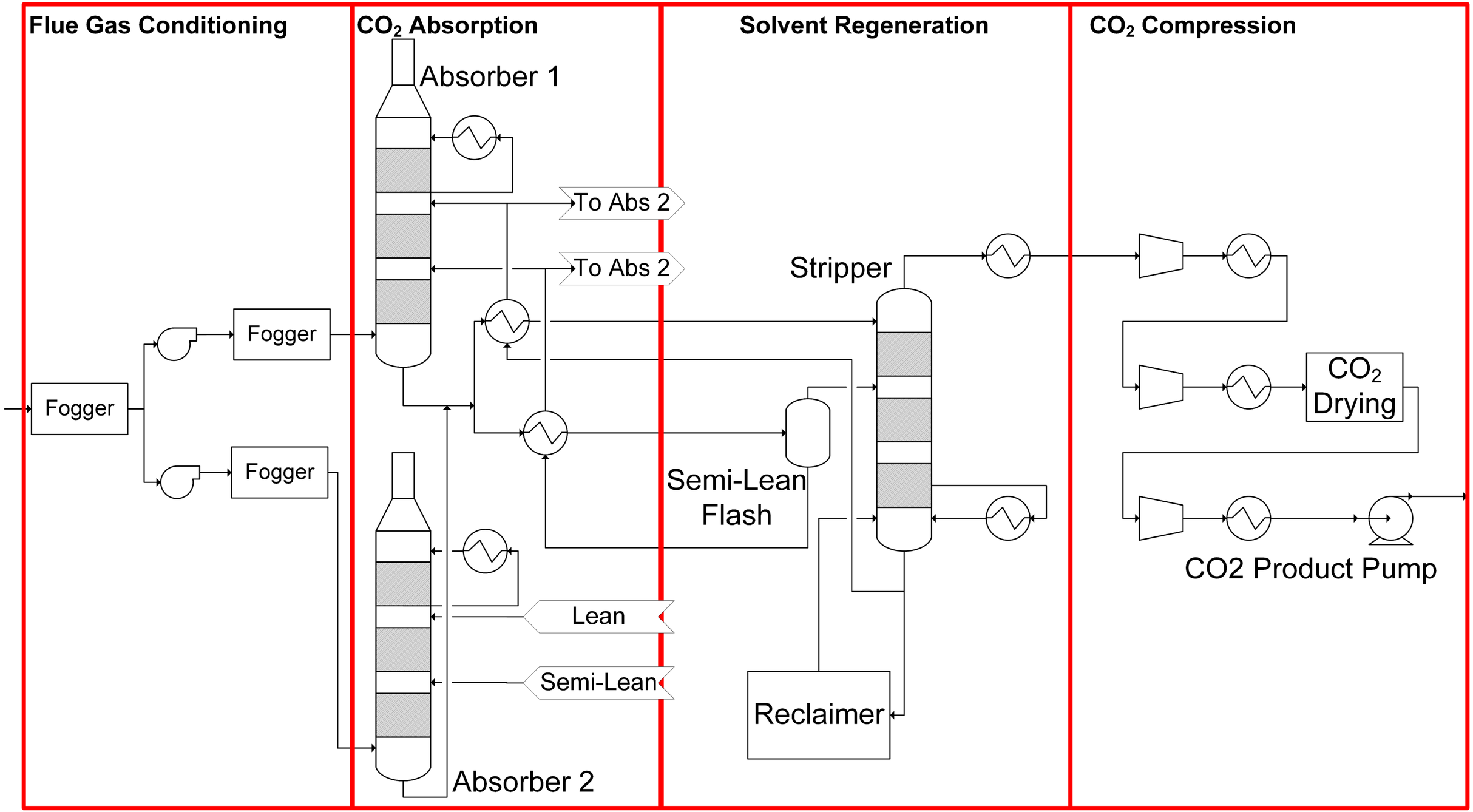
Design Decisions

	Mustang	Panda
Solvent	5 m PZ (~30 wt%)	35 wt% MEA
Steam	Package boilers	Steam extraction
Cooling	Air cooling	Cooling water from existing site capacity
Cost Estimate	Bottom-up cost estimate: • Vendor quotes for major equipment • Piping, ductwork, I&E, civil, etc. estimated from detailed site layouts	
	-20% to +30%	+/- 20%

Capital Cost

Cost ($ Millions)	Mustang	Panda
Total cost	**$724**	**$477**
Direct cost, as reported	$385 ($A$)	$450 ($A$)
Detailed eng. & commissioning	$37 ($B_1$)	$59
Indirect field costs	$93 ($B_2$)	
Contingency	$104 (Excluded)	$34 ($C$)
Owner's cost	$27 (Excluded)	$5 ($D$)
Contractor's ovhd & profit	$60 ($E$)	(Included)
Adjusted direct field cost	**$574** $A + B_1 + B_2 + E$	**$411** $A - C - D$

Panda Flowsheet



Costs by Process Area

	Mustang		Panda	
Flue Gas Handling	HRSG to Abs: 600 [ft] No quench	**9%**	**29%**	HRSG to Abs: 1290 [ft] Water fogging
CO_2 Absorption	Includes air coolers Rectangular absorber No trim cooler Pumparound	**58%**	**34%**	Cooling water from existing cooling towers Cylindrical absorber Trim cooler No pumparounds

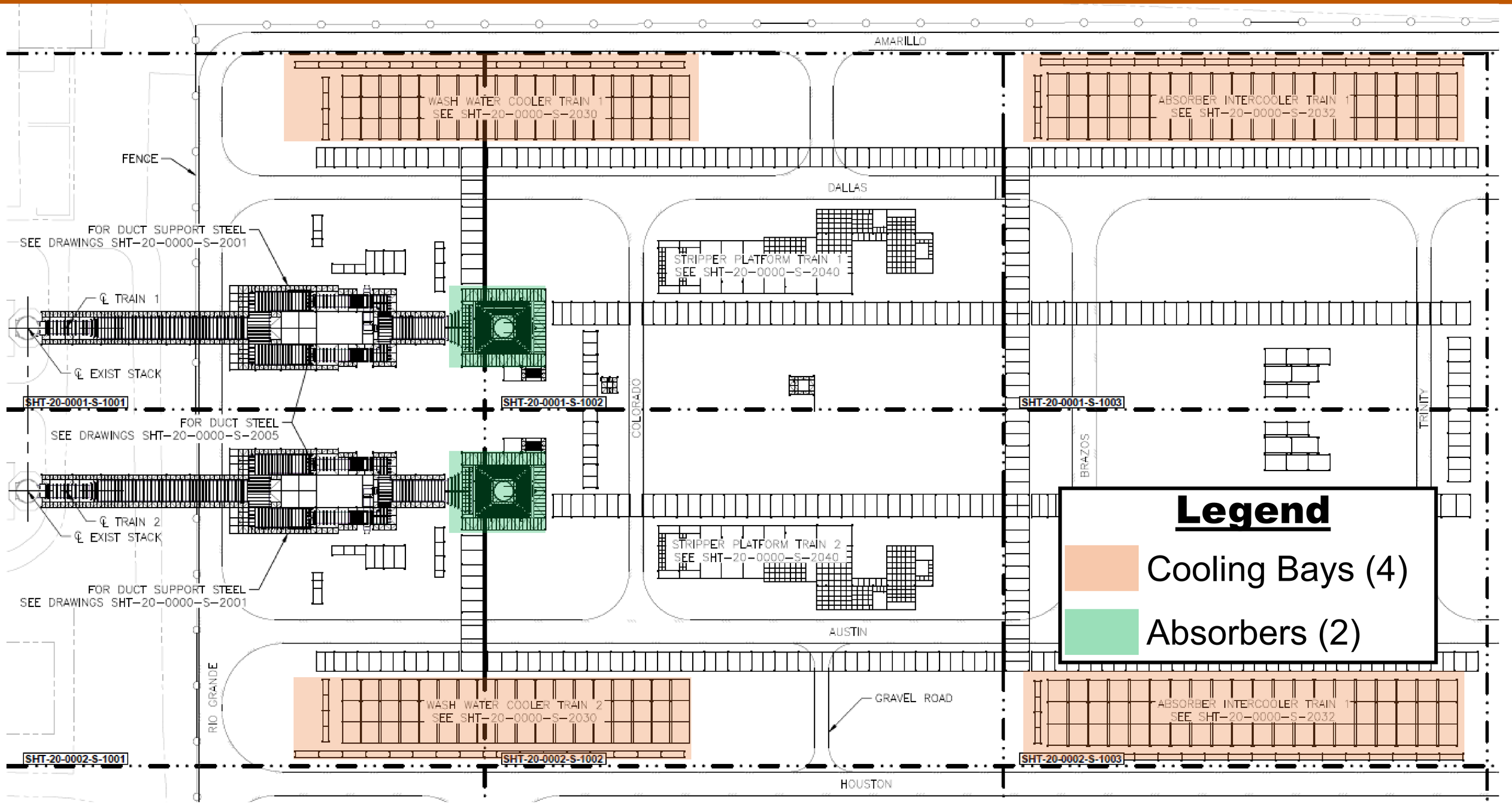
Percentages indicate direct field cost for each process area

Costs by Process Area

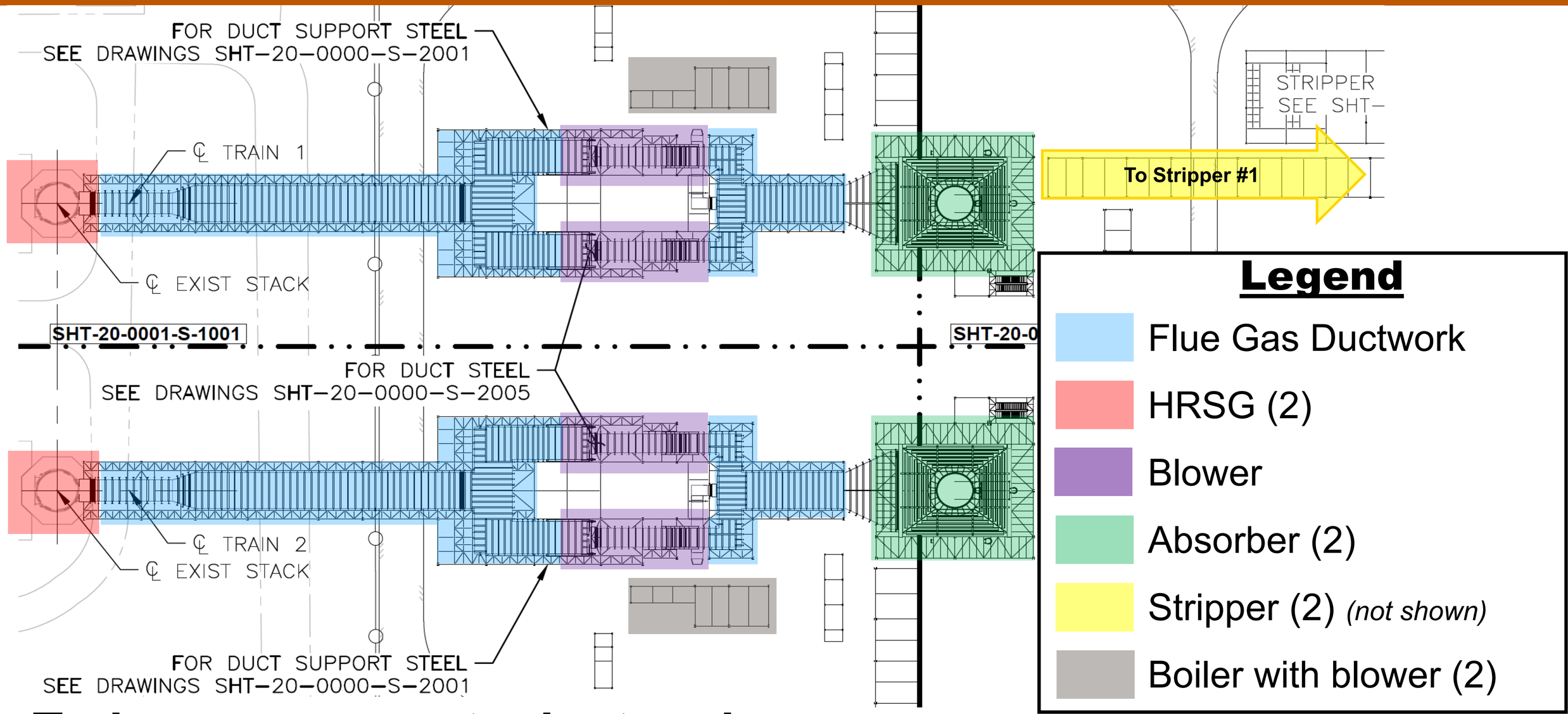
	Mustang		Panda	
Steam Generation	Package boilers + associated equipment	**7%**	**N/A**	
Solvent Regeneration	2x strippers Pressure: 5.6 [bara] 3x 2-stage vacuum reclaimers	**16%**	**18%**	1x stripper Pressure: 2.3 [bara] 2-stage flash reclaimer
Compression	2x 3-stage reciprocating	**10%**	**19%**	1x 3-stage centrifugal Heat integrated

Percentages indicate direct field cost for each process area

Air Cooling – Mustang



Site Arrangement – Mustang



Trains use separate ductwork

600 ft (per train)

Site Arrangement – Panda

Legend

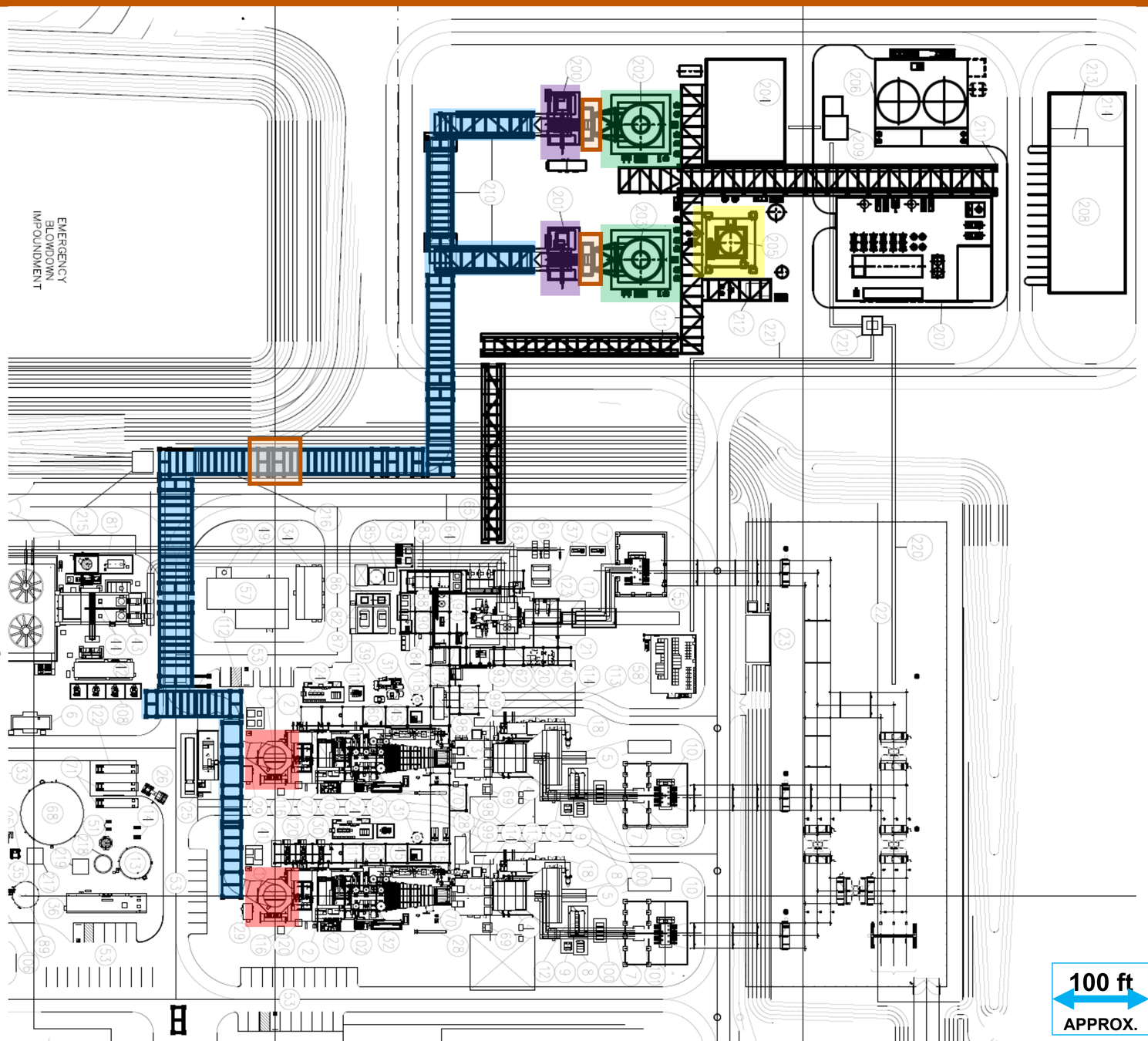
- Flue Gas Steel Rack
- HRSGs (2)
- Blower
- Absorbers (2)
- Stripper (1)
- Foggers (3)

Common duct to absorbers

Carbon steel: 565 ft

Stainless steel: 725 ft

Total: 1290 ft



Direct cost of each process sub-area scaled with flue gas flow rate or CO_2 flow rate:

$$Cost_{scaled} = Cost_{FEED} \times \left(\frac{CF_{Panda}}{CF_{Mustang}}\right)^{(0.6)}$$

- Flue gas flow at Panda is 81% of Mustang
- CO_2 capture flow at Panda is 69% of Mustang

Scaling intended to represent estimated cost for **same PZAS process configuration** and **same host site constraints** (ductwork, package boilers, air cooling, etc.), but with the **design flows of the Panda FEED**.

Cost ($ Millions)	Mustang - Adjusted	Mustang - Scaled	Panda - Adjusted
TOTAL	$574	$489	$411

Absorber Comparison

Absorber Design		1 Mustang FEED	2B Mustang Alternate	3 Panda FEED	3S Panda Scaled
FG to absorber	*t/hr*	1580	1580	1267	
Cross-section		Rectangular	Round	Round	Round
Cross-section area	m^2	175	175	109	175
Packed height	*m*	10.6	10.6	19.0	10.6

Absorber 3S represents Absorber 3 (Panda) scaled to same cross-section area and packed volume as Absorber 1 (Mustang)

Absorber Comparison

Absorber Design		1 Mustang FEED	2B Mustang Alternate	3 Panda FEED	3S Panda Scaled
Material cost	*$MM*	11.3	10.7		
Labor cost	*$MM*	7.2	10.2		
Total cost (reported)	***$MM***	**18.5**	**20.9**	**16.0**	**16.2**
Adjustment for scope	*$MM*	-1.7	-1.0		
Contingency	*$MM*		-1.7	-1.3	-1.3
Contractor overhead	*$MM*	+2.9			
Cost of scope	***$MM***	**19.7**	**18.2**	**14.7**	**14.9**

Scope includes single absorber with engineered procurements and steel, excludes foundation, instrumentation, piping, pumps

Conclusions

- Adjusted direct field costs: $574MM Mustang to $411MM Panda
- Scaling Mustang to Panda capacity: $493MM (M) to $411MM (P)
- Rectangular absorber appears 10% to 30% more expensive than cylindrical designs, with higher material costs and lower labor costs
- Absorber estimates adjusted to same scope, dimensions, and packed volume: $19.7MM, $18.2MM, $14.9MM
- Academic studies use simple cost models, neglect significant costs especially site-specific factors (e.g., layout, steam extraction, water)

Future Work

- Collaborating with Bechtel to refine FEED comparison for publication and upcoming poster presentation at GHGT-16 conference (October 2022)

- Beginning yearlong project sponsored by ExxonMobil
  - Design and optimization of CCS for cogeneration applications
  - Develop gPROMS® process design/cost estimation model
  - **Apply learnings from cost comparison to develop CAPEX model**
  - Rigorous optimization to reduce costs, perform sensitivity analysis

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