Assessment of a Modularized CO_2 Capture Membrane System

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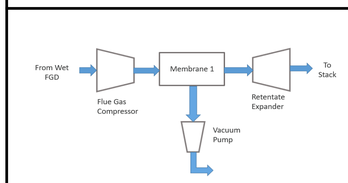
Motivation

- Modular capture systems could facilitate the addition of carbon capture for existing CO_2 sources due to the potential for more simple installation (compared to solvents) and lower cost
- Membranes are especially promising as they can avoid potentially costly or complicated plant integrations, such as steam extraction

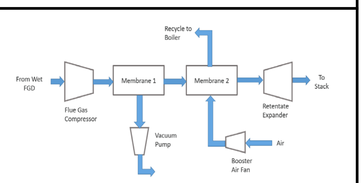
Study Approach

- 300 MW supercritical pulverized coal unit chosen as CO_2 source, base layout taken from recently constructed plant in Indonesia
- Plate-and-frame membrane stacks housed in 40’ x 8’ x 8’ conex shipping containers are the modular unit
- Analyzed 1,700 GPU (low performance [LP]) and 3,000 GPU (high performance [HP]) membrane materials
- Required membrane areas calculated using co-current membrane model, assumed 120 m^2 membrane area per rack
- Greenfield and retrofit sites assessed, with separate membrane configurations for each site type

Retrofit, 50% Capture



Greenfield, 90% Capture



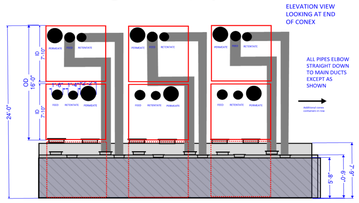
	Membrane 1		Membrane 2	
	Membrane Area (m^2)	Racks Required	Membrane Area (m^2)	Racks Required
HP Retrofit	58,529	488	---	---
LP Retrofit	104,051	867	---	---
HP Greenfield	110,555	921	260,129	2,168
LP Greenfield	195,056	1,626	390,193	3,252

Layout Approach

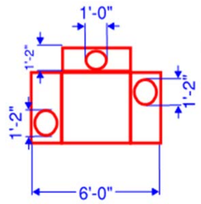
- Retrofit layout assumes all structures and equipment are fixed
- Greenfield layout assumes structures and equipment can be modified to best fit the capture system
- Membrane stack design is based on site conditions and membrane performance
- Conex are stacked three levels high with one empty conex as a base to provide room for large transport duct connections

Layout Approach (cont’d)

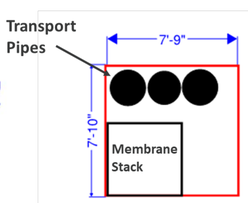
Conex Stacking and Duct/Pipe Connection



Stack Plan View



Internal Conex Elevation View

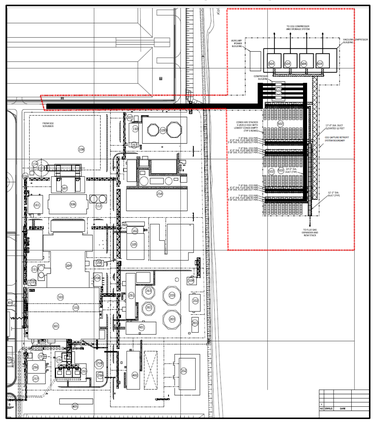


- Stack height (# of racks) treated as design variable due to space constraints in the conex for required piping
- Installed racks include 5–10% spare capacity

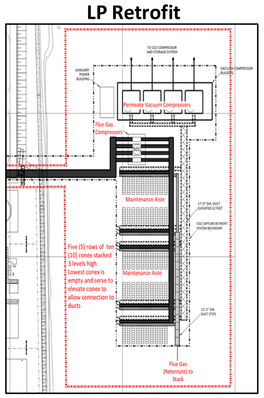
			Membrane 1				Membrane 2			
	Total # of Conex	# of Empty Conex	# of Conex w/ Racks	Racks Per Stack	Stack Per Conex	Racks Installed	# of Conex w/ Racks	Rack Per Stack	Stack Per Conex	Racks Installed
HP Retrofit	132	44	88	2	3	528	---	---	---	---
LP Retrofit	150	50	100	3	3	900	---	---	---	---
HP Greenfield	540	270	126	2	4	1,008	144	4	4	2,304
LP Greenfield	576	288	144	3	4	1,728	144	4	6	3,456

Site Layouts

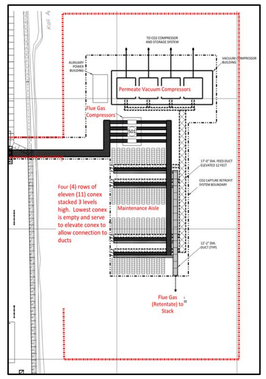
Retrofit Generating Unit with Membrane Capture System



LP Retrofit

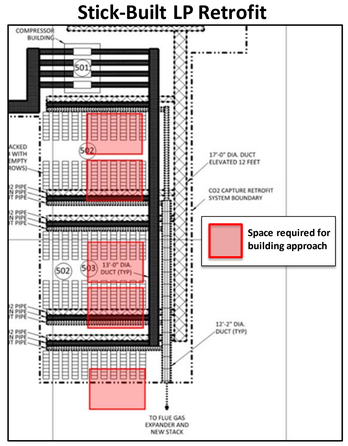


HP Retrofit



- Retrofit site requires extensive ductwork to transport flue gas from desired generating unit
- HP membrane material does not provide significant footprint reduction due to space constraints within conex
- Stick-built site has a smaller footprint than low performance conex case
- Greenfield site layouts are not shown but are available in the report

Stick-Built LP Retrofit



Cost Comparisons

	BEC	Total Plant Cost (TPC)	
	$1,000	$1,000	$/kW (gross)
HP Retrofit	133,877	200,189	667
LP Retrofit	139,590	213,392	711
HP Greenfield	262,167	405,457	1,314
LP Greenfield	274,512	424,865	1,378
Stick-Built LP Retrofit	136,042	203,367	678
Partial Modular LP Retrofit	200,679	310,650	1,035

- HP cases only provide slight cost benefit compared to LP cases, as increased performance creates additional conex space issues
- Stick-built case provides significant space savings but only a ~10% reduction in cost since auxiliary equipment drives TPC

Conclusions

- Retrofit membrane layouts will likely require large duct runs to reach open space available for capture system footprint
- Use of baghouse design/sparing philosophy is beneficial for membranes by providing isolation capability and economy-of-scale benefits for auxiliary equipment
- Diameter of piping within conex containers limits the feasible height of the membrane stacks
- Conex limit ability to optimize membrane stack configuration, arrangements, and sizing due to the internal height restrictions
- Confined space restrictions within the conex pose issues both for shop manufacturing as well as maintenance
- Conex use provides limited to no benefit for greenfield site due to large footprint, high costs, boiler recycle requirement, and limited schedule benefits
- Stick-built provides best opportunity for optimizing membrane design to achieve smaller footprint requirements
- Operating and maintenance costs for membrane replacement will be lower for the stick-built case due to better access

Disclaimer

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