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High Performance Solvent for NGCC Flue Gas CO_2 Capture

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Location: Delta Hotel Philadelphia Airport
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Sustenol™ for NGCC Flue Gas CO_2 Capture

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Sustenol™
is a water-lean mixed amine solvent, developed by Susteon

1 *High CO_2 Capture Rate*

- ✓ **>97% CO_2 Capture**
  L/G = 0.7 → To reach Net-zero DOE target
- ✓ **20% lower surface tension**
  indicating better wettability
- ✓ **Double the reaction rate**
  lowers the required column height

2 *Low CAPEX*

>30% projected capital cost reduction

- ✓ **57% higher working capacity**
  proportionally reduced solvent circulation rate
- ✓ **<10 cP viscosity at 40ºC**
  better mass transfer rate for CO_2-rich condition

3 *Low OPEX*

>15% projected operating cost reduction

- ✓ **50% lower regeneration energy**
  < 2.2 GJ /t. CO_2 reboiler duty
- ✓ **0.0001x vapor pressure**
- ✓ **Lower oxidative, thermal and hydrothermal degradation**
  when exposed to air and higher temperatures

compared with 30 wt.% MEA

Sustenol™ Test System for Solvent Optimization

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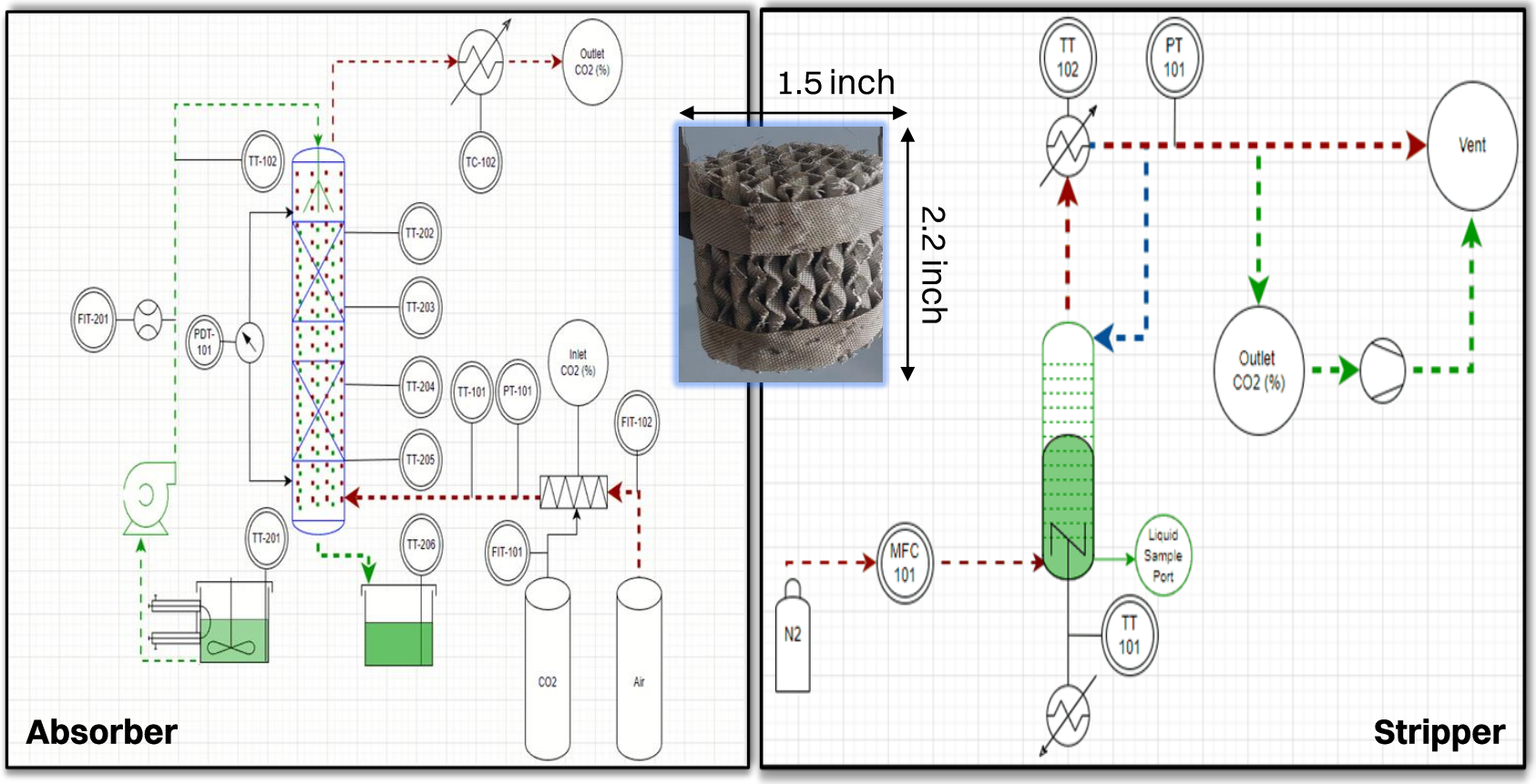

Absorber	
Packing diameter	1.5 inch
Packing height	4 ft
Column flooding	70%-80%
Gas flow	60 slpm
Liquid flow	10-100 g/min
H_2O	5-7 mol%
CO_2	4-5 mol%
N_2	70-80 mol%
O_2	8-12 mol%

Stripper	
Packing Diameter	1.5 inch
Packing Height	7 ft
Column Flooding	70%-80%
Reboiler Temperature	105-115°C
Reboiler Duty	1800 W

Sustenol™ CO_2 Capture Performance – 4% CO_2 in Flue Gas

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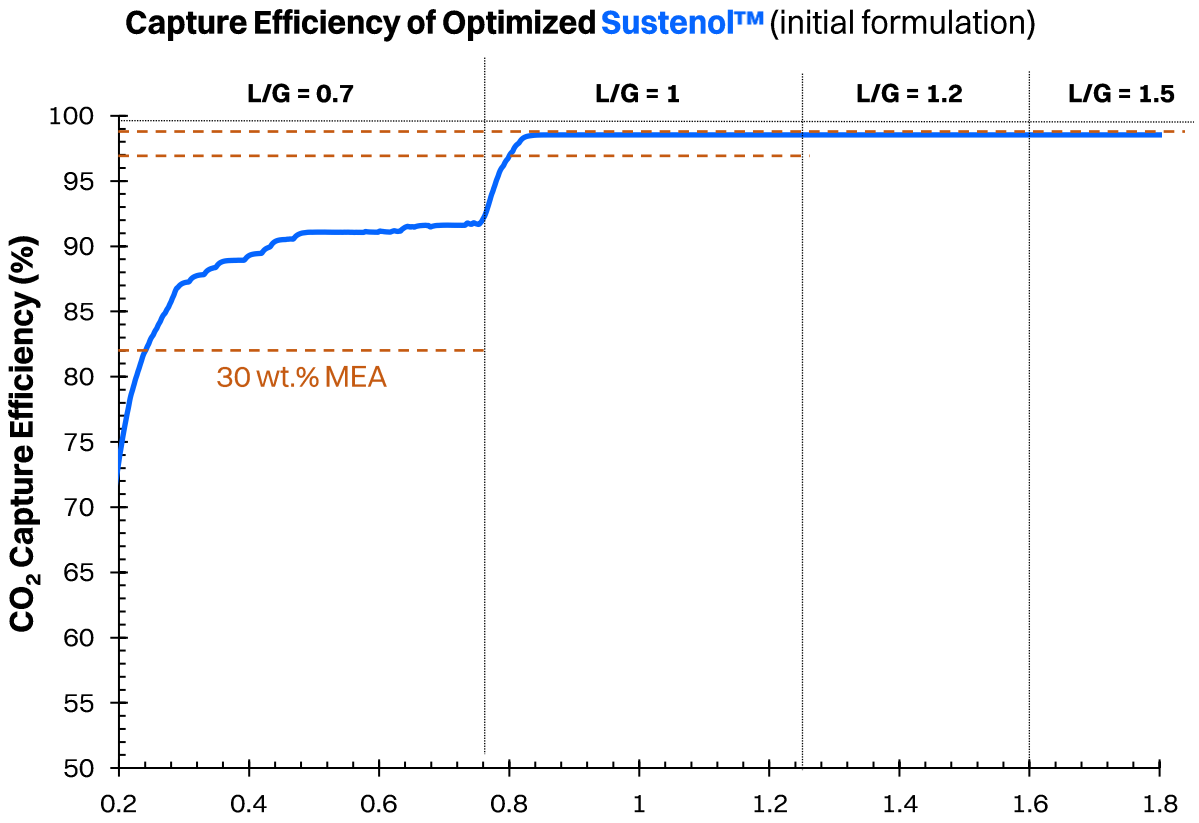

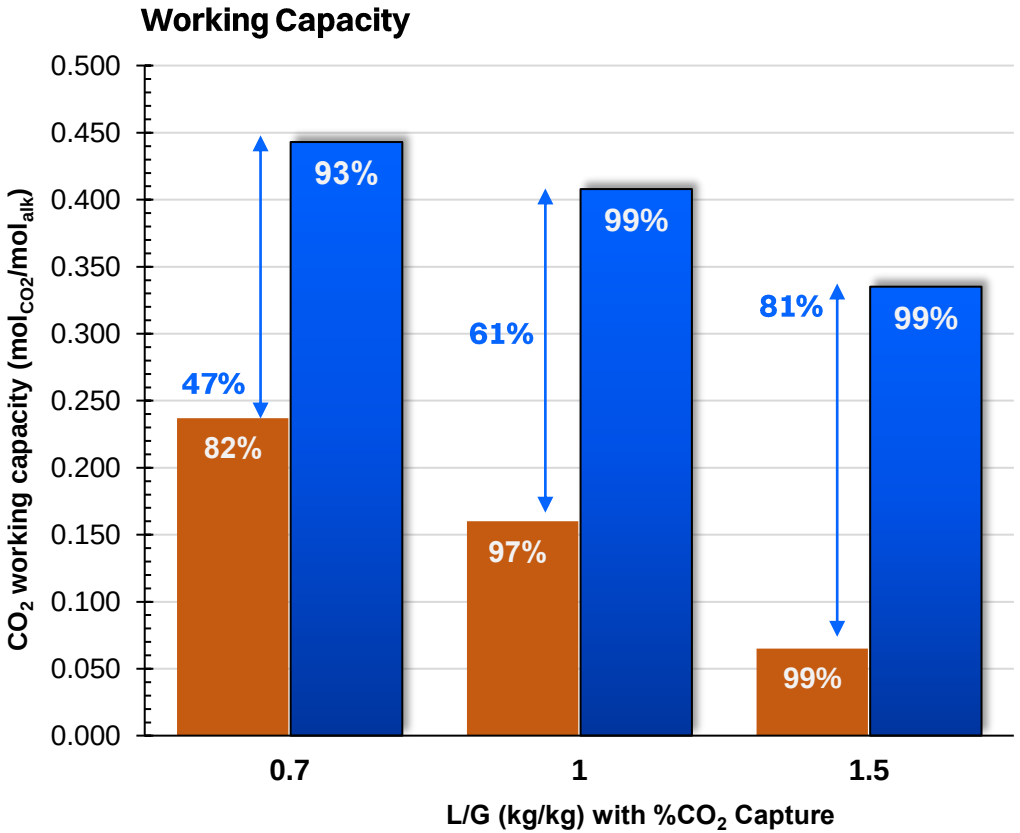

Initial formulation of Sustenol™ shows **a higher working capacity** – up to **81% increase** (at L/G of 1.5)

Optimized Sustenol™ for High Capture Rates at a Low L/G

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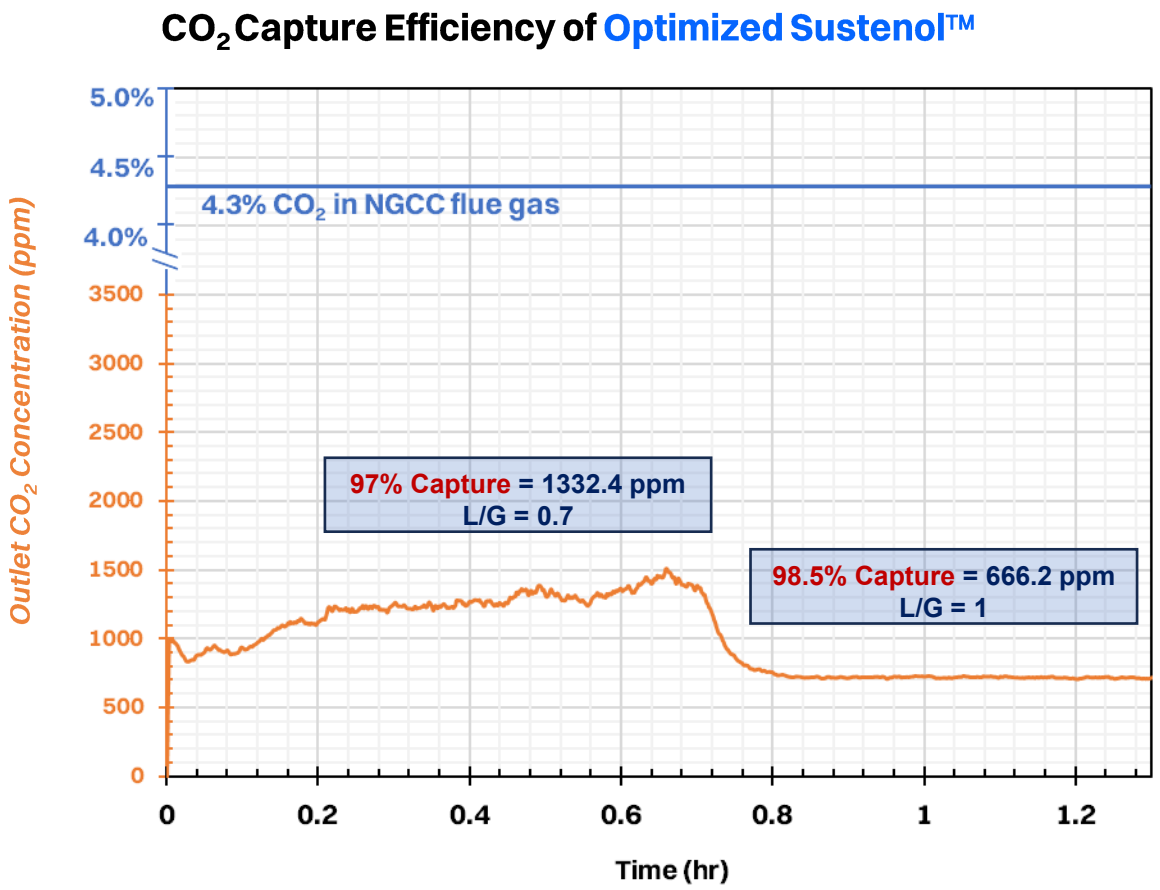

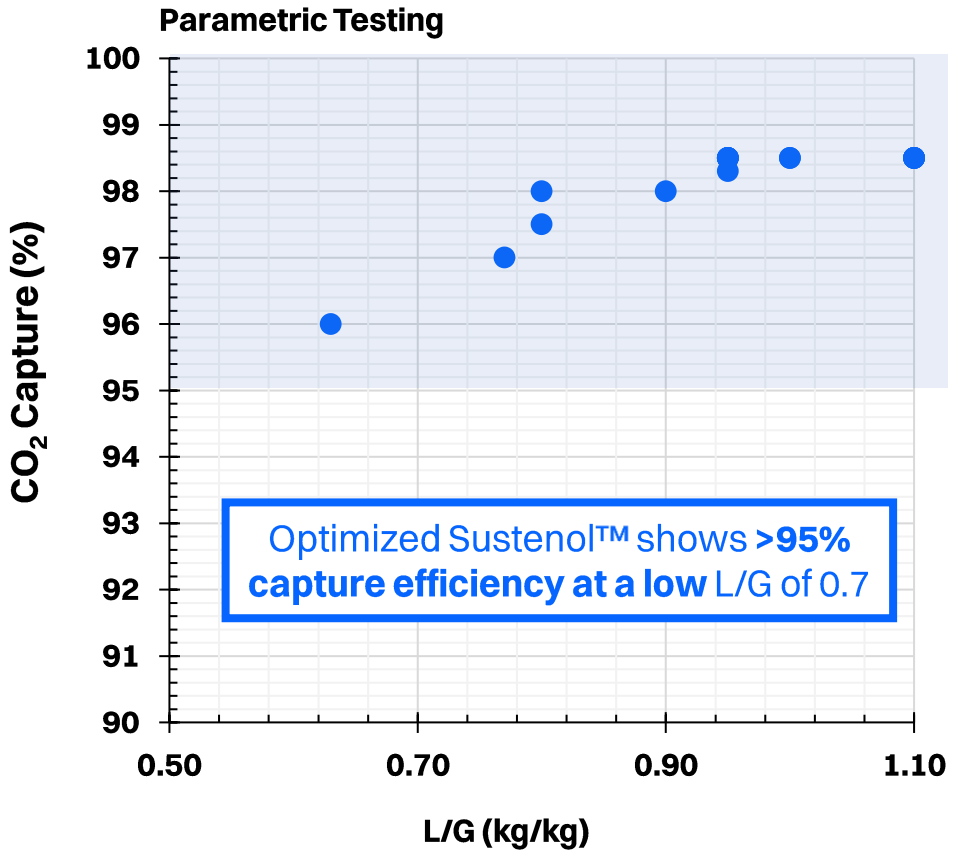

Optimized Sustenol™ for High Capture Rates at a Low L/G

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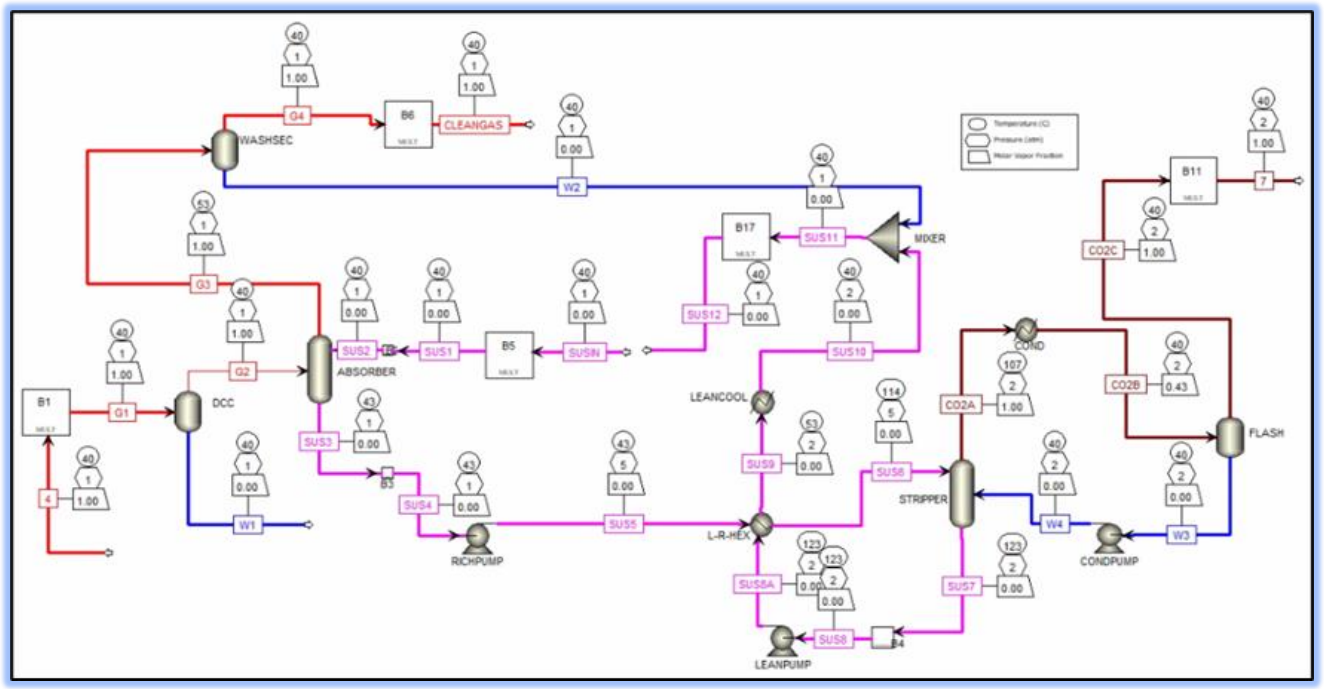
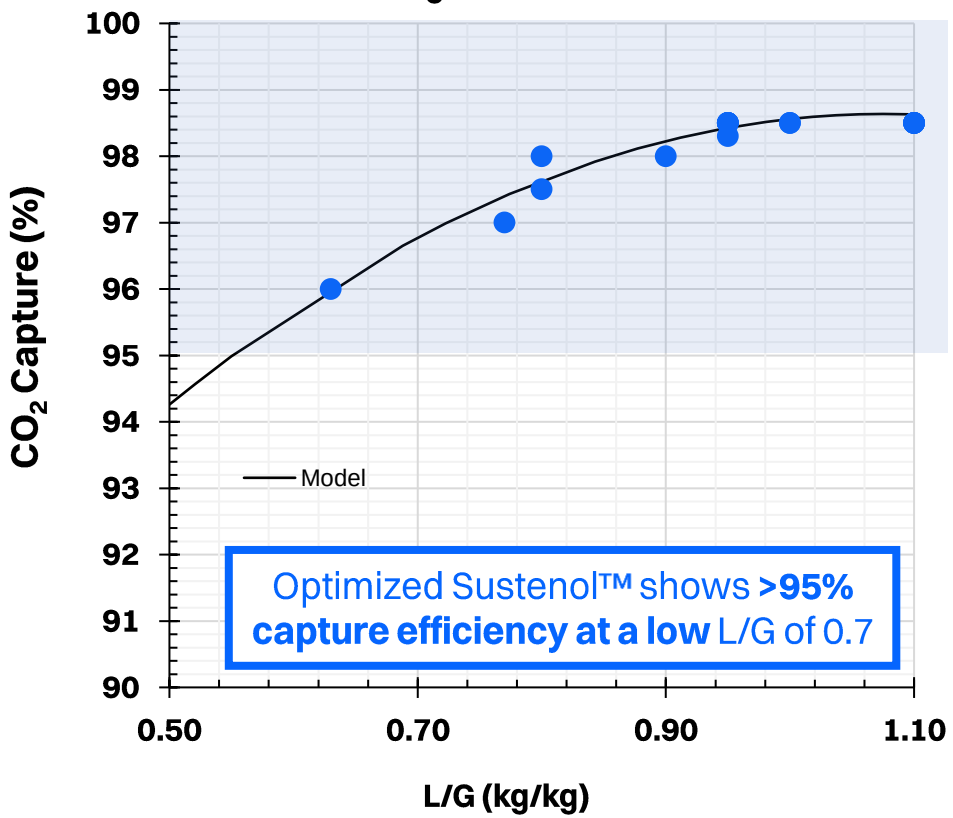
Scaled-up process model (rate-based) to commercial scale (6000 tonne/day)



Parametric Testing



Property Estimation of Optimized Sustenol™

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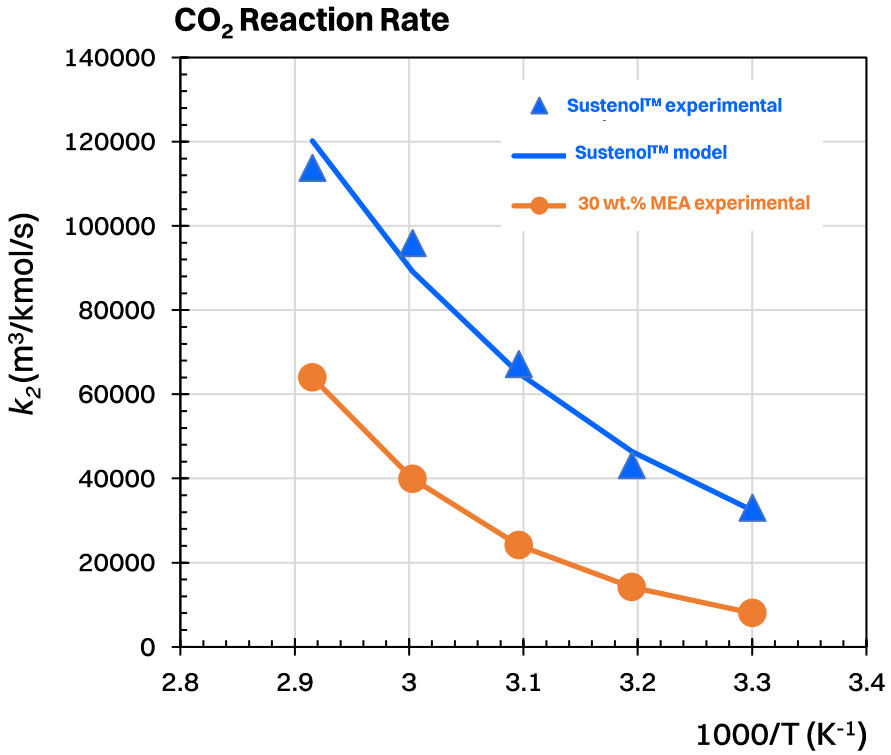

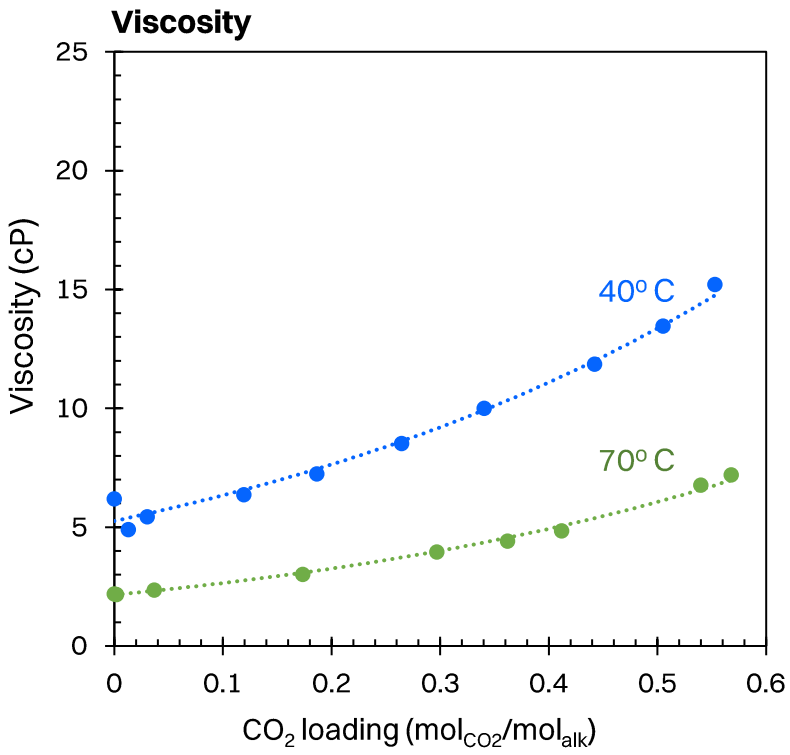

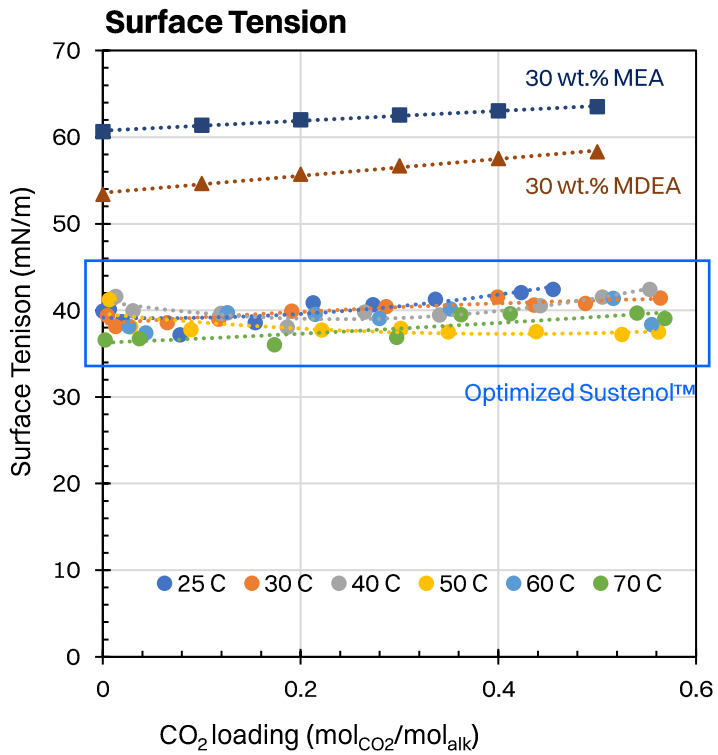

High reaction rate → **Lower absorber height**

Low viscosity → **Higher mass transfer**

Low surface tension → **Higher wettability**

Property Estimation of Optimized Sustenol™

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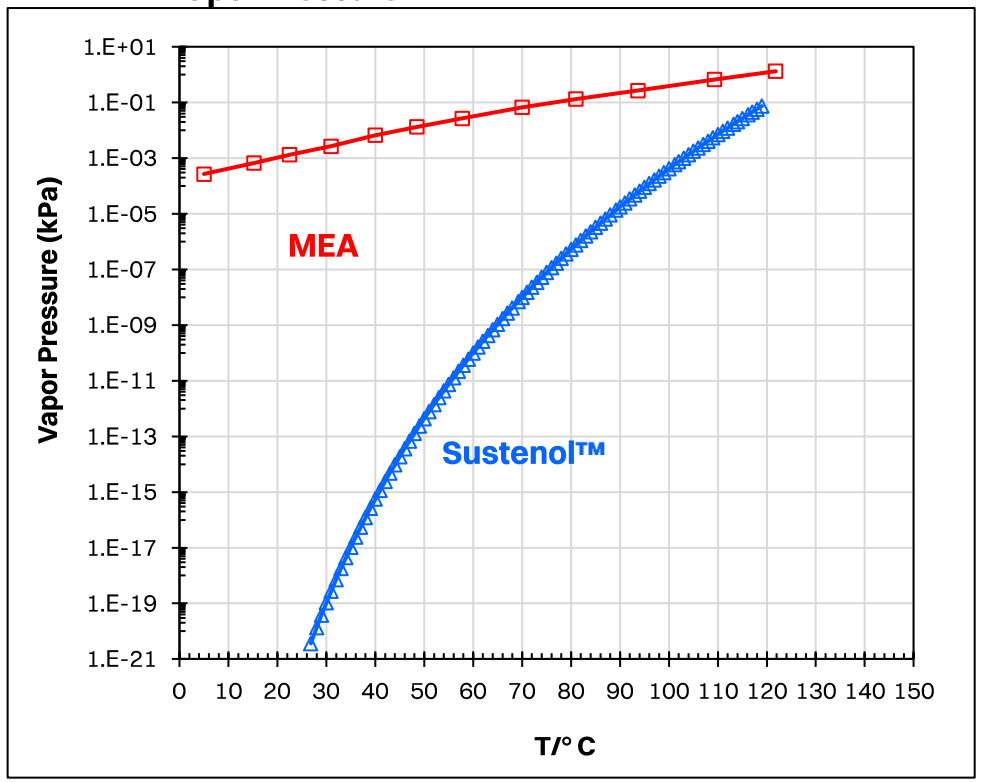
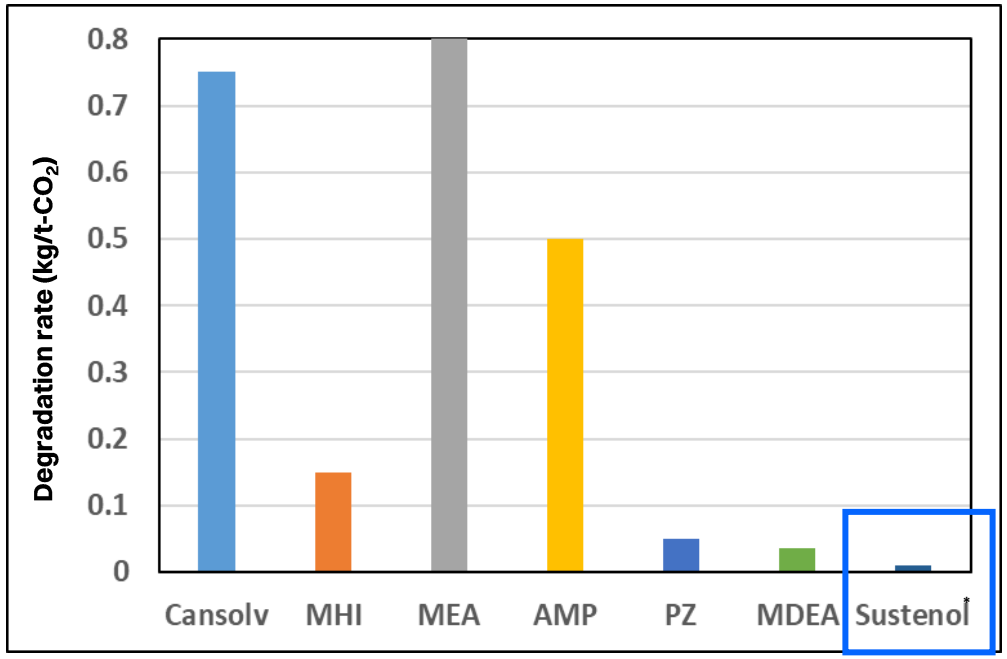
Vapor Pressure



Lower vapor pressure → **Lower solvent loss**

Degradation*



Lower degradation → **Lower make-up rate**

*Estimated degradation rate from individual components

[2,3] Lower CAPEX and OPEX

Reduction in Reboiler Duty

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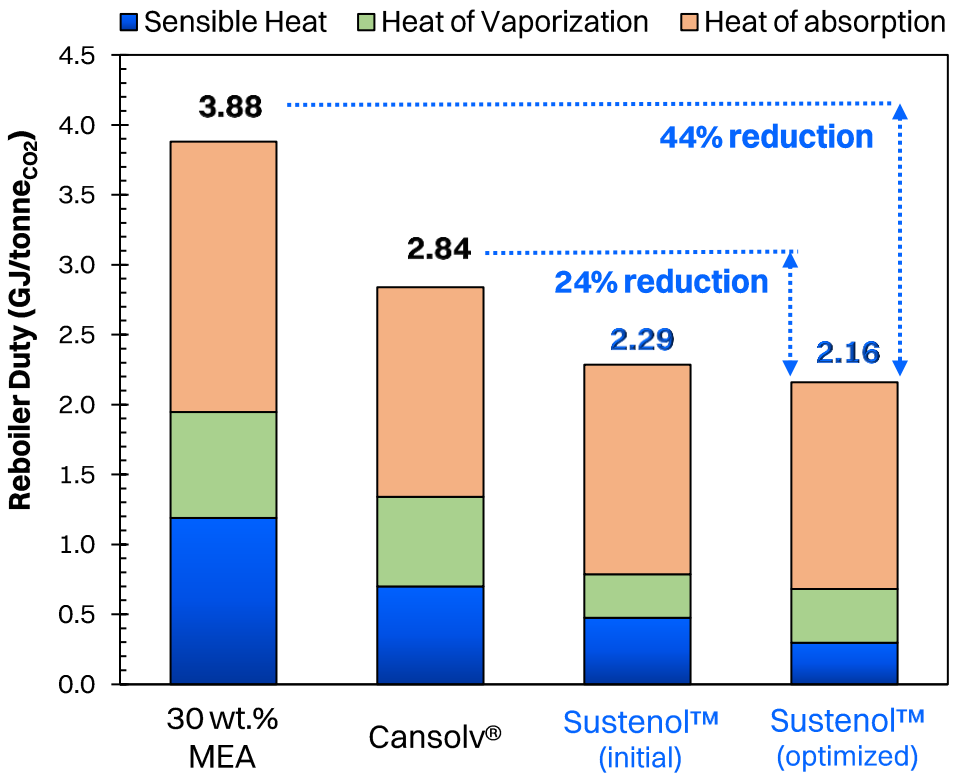
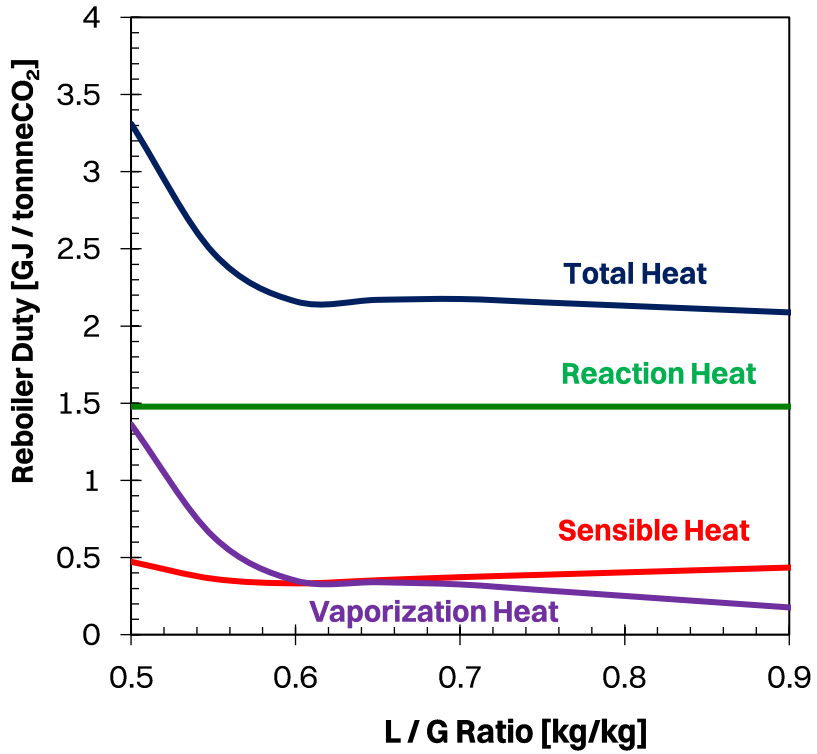
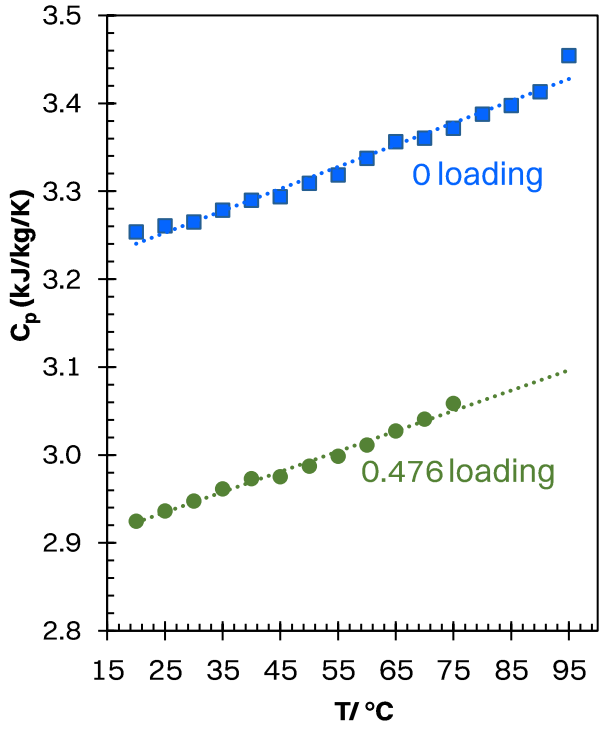
Estimated regeneration energy based on rich CO_2 loading at 40°C and 4% CO_2 in flue gas



Heat Capacity





Low reboiler duty + Low sensible heat → **Low operating cost (OPEX)**

Marginal Costs at High Capture Rate (beyond 90% capture)

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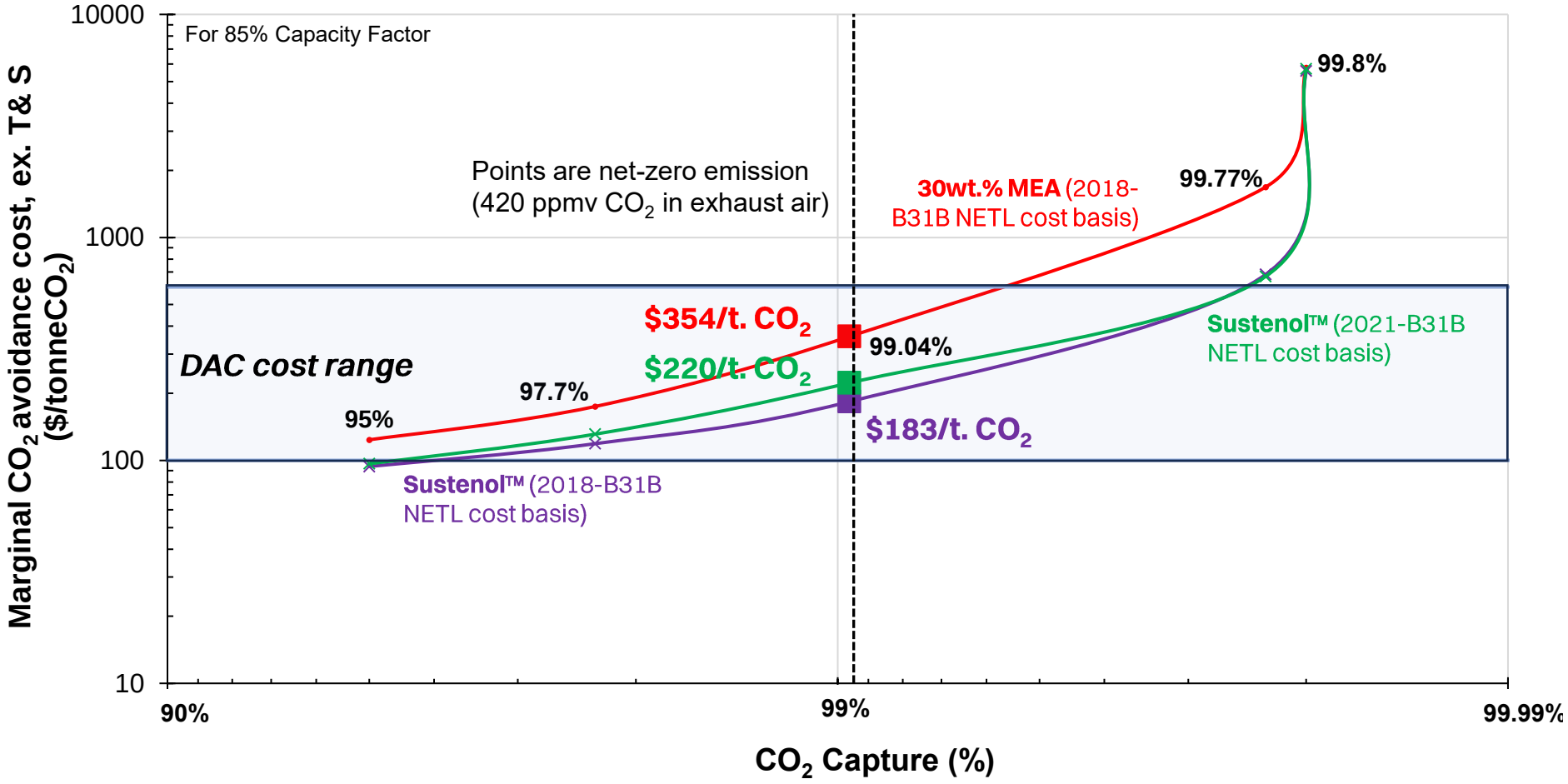

1 TPD CO_2 Capture System for Continuous Testing (In Progress)

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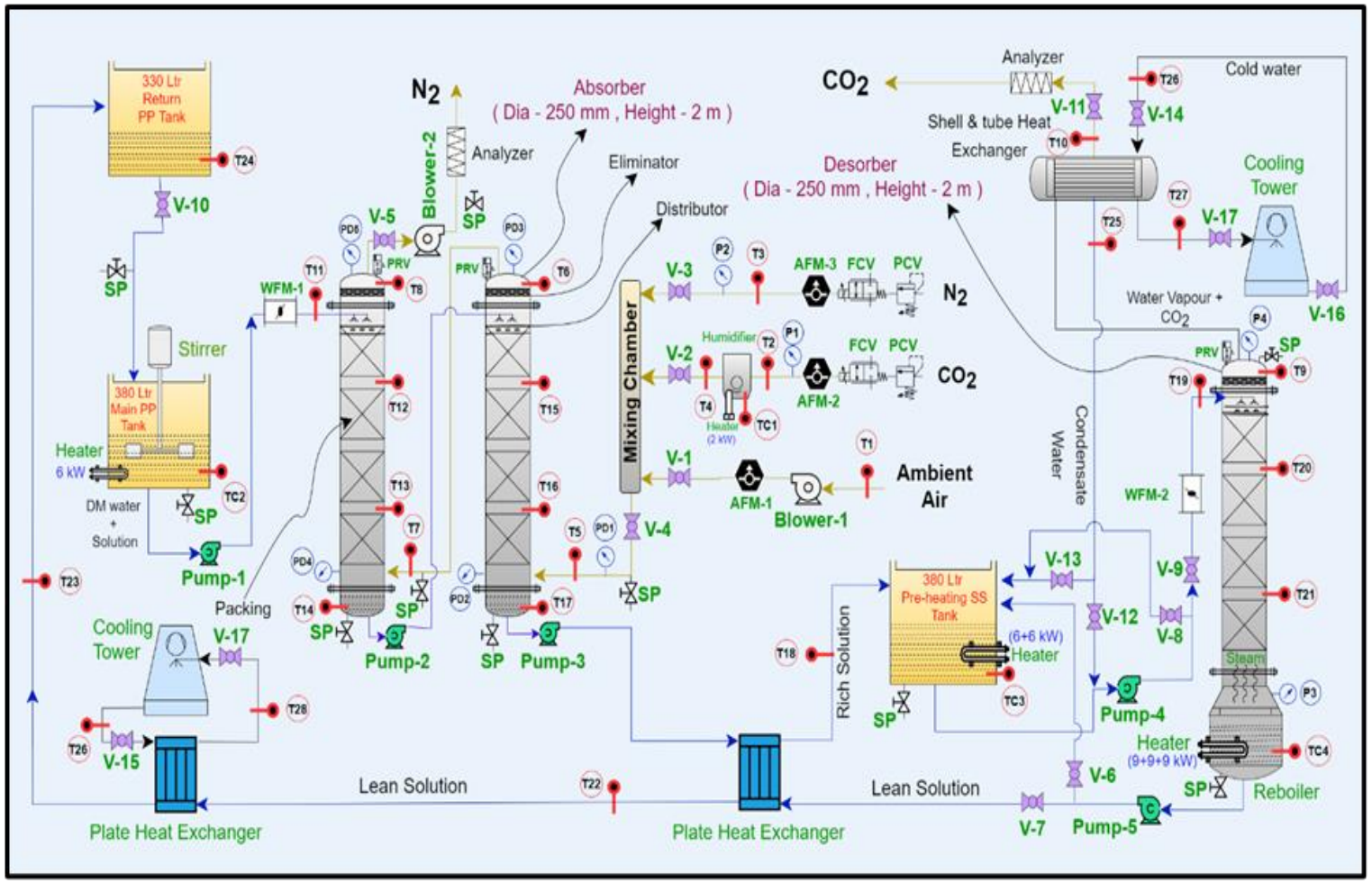

Conventional Absorber	
Packing Diameter	250 mm
Packing Height	2 × 2 m
L/G (kg/kg)	0.7-4
Gas flow	1000-4000 lpm
Liquid flow	3-10 lpm
H_2O	5-7 mol%
CO_2	4-5 mol%
N_2	70-80 mol%
O_2	8-12 mol%

Desorber	
Packing Diameter	250 mm
Packing Height	2 m
Pressure	1-2 bar
Reboiler Temperature	110-120°C
Pre-heater Duty	12 kW
Reboiler Duty	27 kW

Sustenol™ Testing at NCCC

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View of 0.5-MW PSTU

NATIONAL CARBON CAPTURE CENTER

Engineering Scale Testing of Sustenol™ for NGCC Flue Gas CO_2 Capture

Test the drop-in Sustenol™ solvent at NCCC using the pilot-scale solvent test unit (PSTU) - 0.5 MW NGCC

- ✓ to confirm and validate its **CO_2 capture performance** (>95% CO_2 capture)
- ✓ to confirm **reboiler duty for solvent regeneration**
- ✓ to test and confirm **carbon steel and 316SS corrosion rates**
- ✓ to refine and update **rate-based process model**
- ✓ to determine **optimum operating window**
- ✓ to demonstrate **stability and emissions** for commercial demonstration and deployment
- ✓ to demonstrate NGCC **flue gas CO_2 capture costs <$45/tonne**

Challenges and R&D needs for high capture rates and flexible operation

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- **Optimize process turndown ratio -** with respect to NGCC power plant load-following operation
- **Optimize solvent flowrate** at high capture rates
- **Lower the lean loading** to increase the driving force at the top of the absorber.
- **Provision for auxiliary steam** during low steam availability
- **Investigate effect of solvent viscosity** for high capture rate
- **Investigate effect of solvent intercooling** along the absorber under high capture rates.
- **Investigate effect of flue gas inlet temperature** on CO_2 capture rate.
- **Control water-balance, aerosol, and vapor emissions** at high CO_2 capture rates.
- **Investigate column liquid flooding levels** and **liquid hold-up** at different operating capacity factors (25% to 85%).

Impacts and issues regarding emissions changes in flexible operation/high capture rates

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- At **lower lean loading**:
  - increased driving force at the top of absorber will have higher temperature bulge at the top
  - increased specific steam requirement
  - increased aerosol emissions at the top of absorber
  - increased intercooling requirements
- **Control emissions** by water wash/acid wash
- **Column wetting** at low flue gas flow rates, which can cause more aerosol emissions
- **Study impact of cost factors and financial assumptions** to better understand the economic viability for zero and negative emissions power plants under various economic conditions.

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is a water-lean mixed amine solvent developed by Susteon

1	*High CO_2 Capture Rate*	**>97% CO_2 Capture (low L/G)** **High reaction rate**
2	*Low CAPEX*	**High working capacity** **>30% lower capital cost**
3	*Low OPEX*	**Half the regeneration energy** **>15% lower operating cost**

Acknowledgement

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