

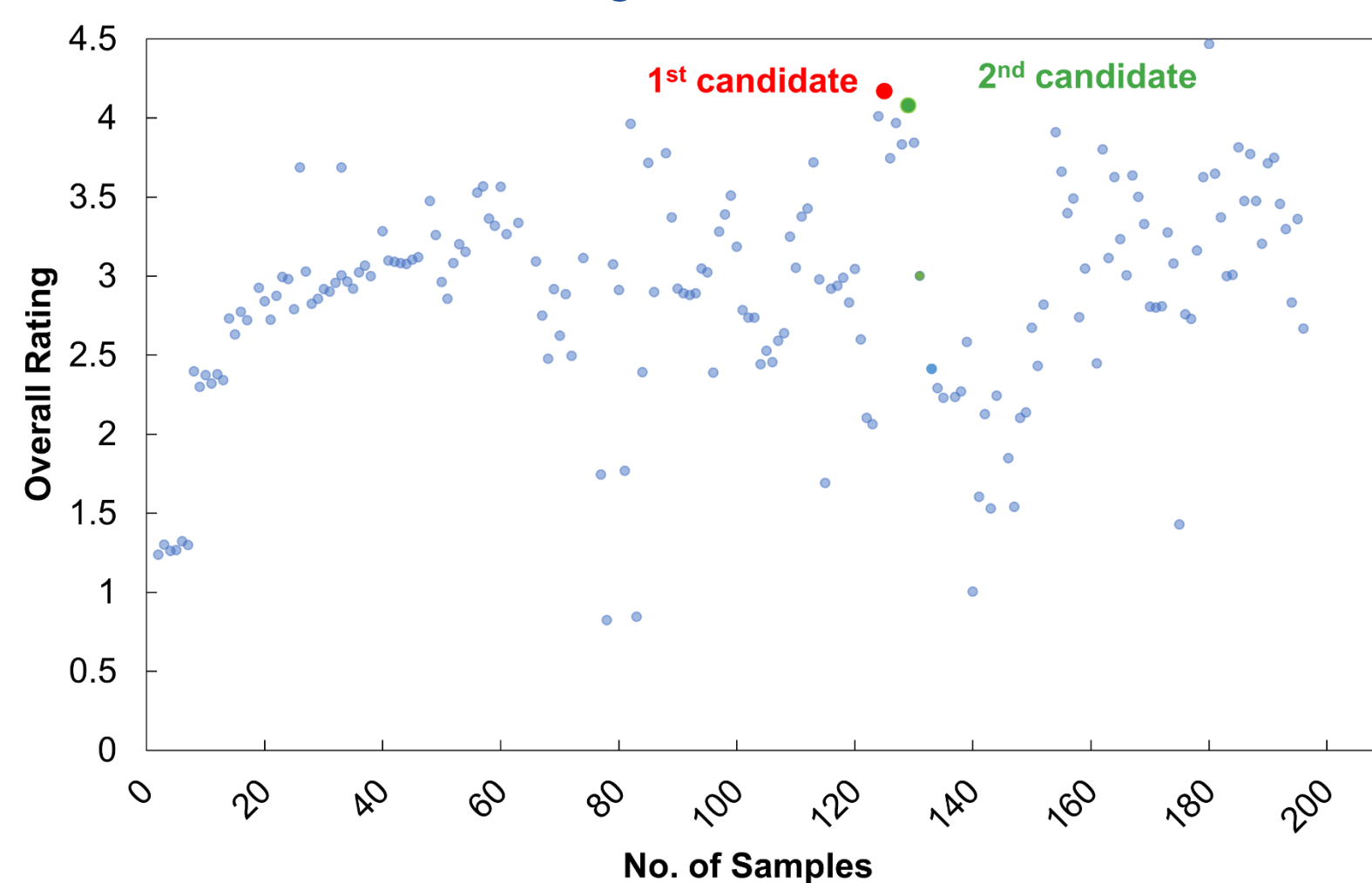
Overview

A novel 2nd generation non-aqueous solvent (GEN2NAS) is specifically designed for superior carbon dioxide (CO₂) capture performance in Natural Gas Combined Cycle (NGCC) operation, with >97% capture rate, 40% cost reduction from DOE baseline study, and lower amine emission

Project Milestones

- Optimization of formulations with high X_{solvent} exhibiting optimal loading and workable viscosity at NGCC conditions
- Demonstration of >500 hr of TOS continuous operation of a selected formulation with >97% CO₂ capture efficiency in the Lab Scale Gas Adsorption System (LsGAS)
- Execution of long-term continuous capture experiments with varying testing parameters in the Bench Scale Gas Adsorption System (BsGAS)
- Estimation of the overall cost of CO₂ capture using GEN2NAS in different configurations from preliminary Techno economic Analysis (TEA)
- Understanding of thermal and oxidative degradation of the capture solvent

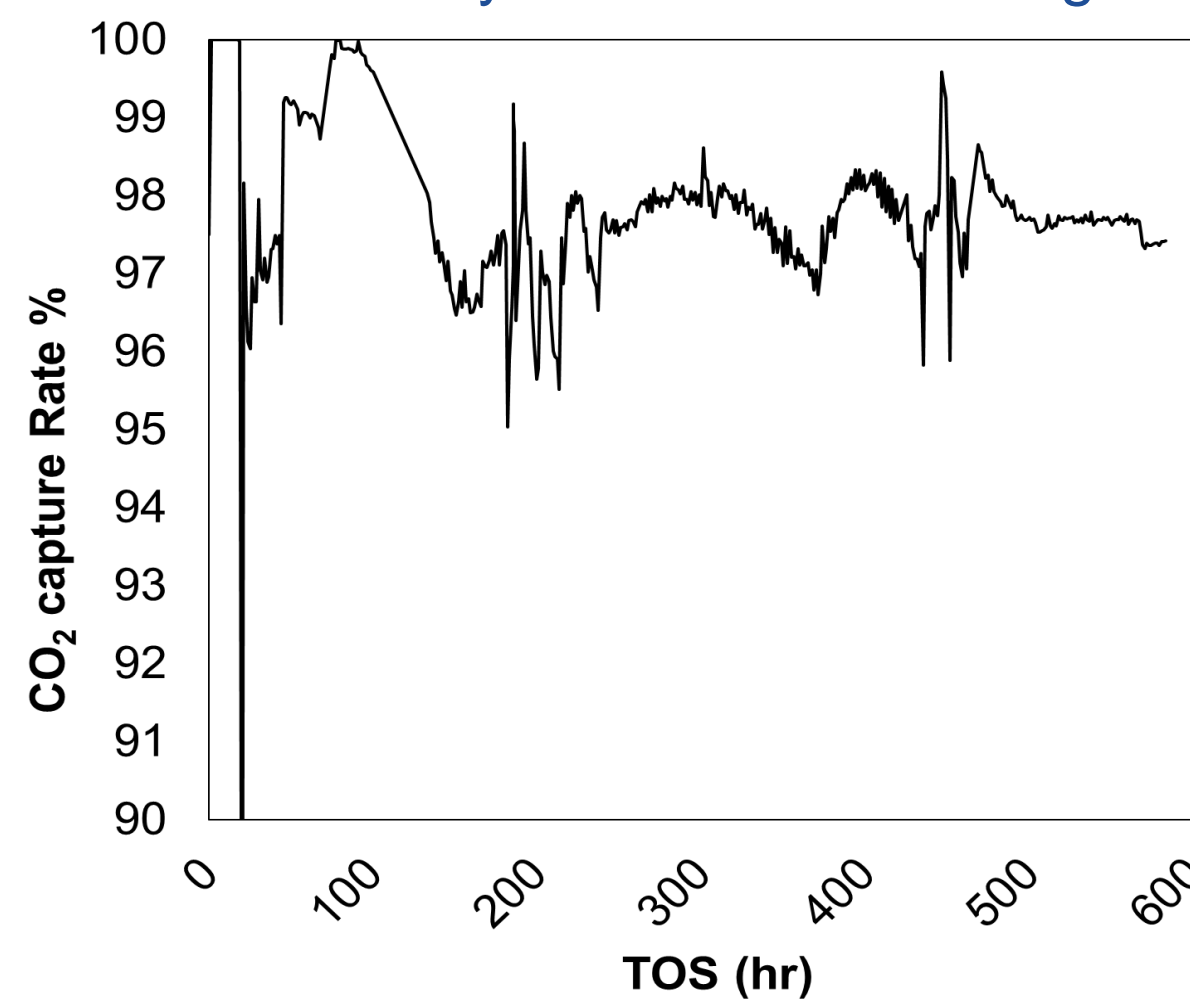
Solvent screening and finalized formulations



Summary of Solvent Screening

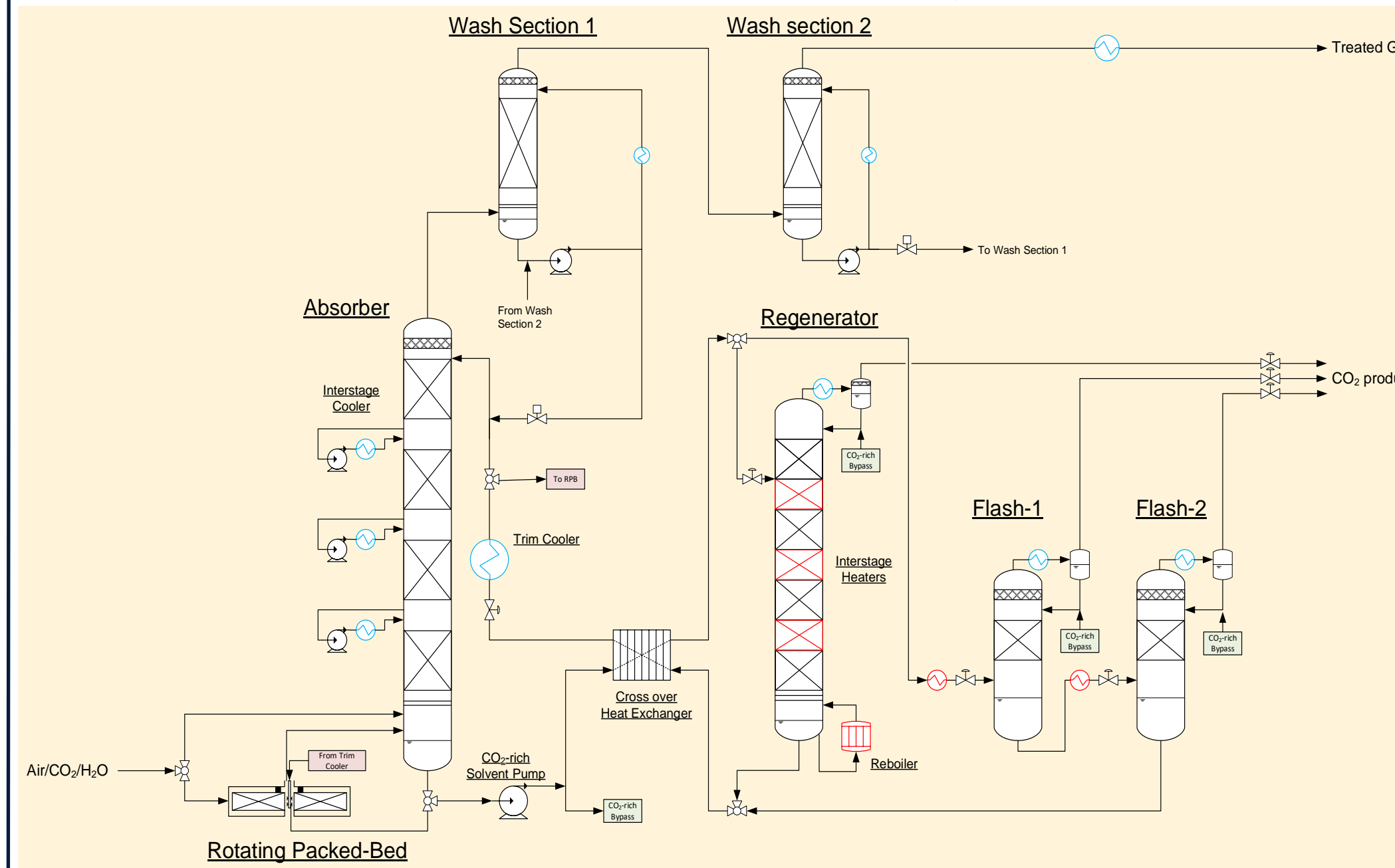
- Combinations of 13 amines and 20 diluents evaluated in total 400 formulations
- Formulations ranked based on solvent cost, viscosity, CO₂ working capacity, vapor pressure, GHS hazard counts, and specific reboiler duty (SRD)
- 2 top candidates selected for LsGAS testing

Summary of Lab-scale Testing Campaign at LsGAS



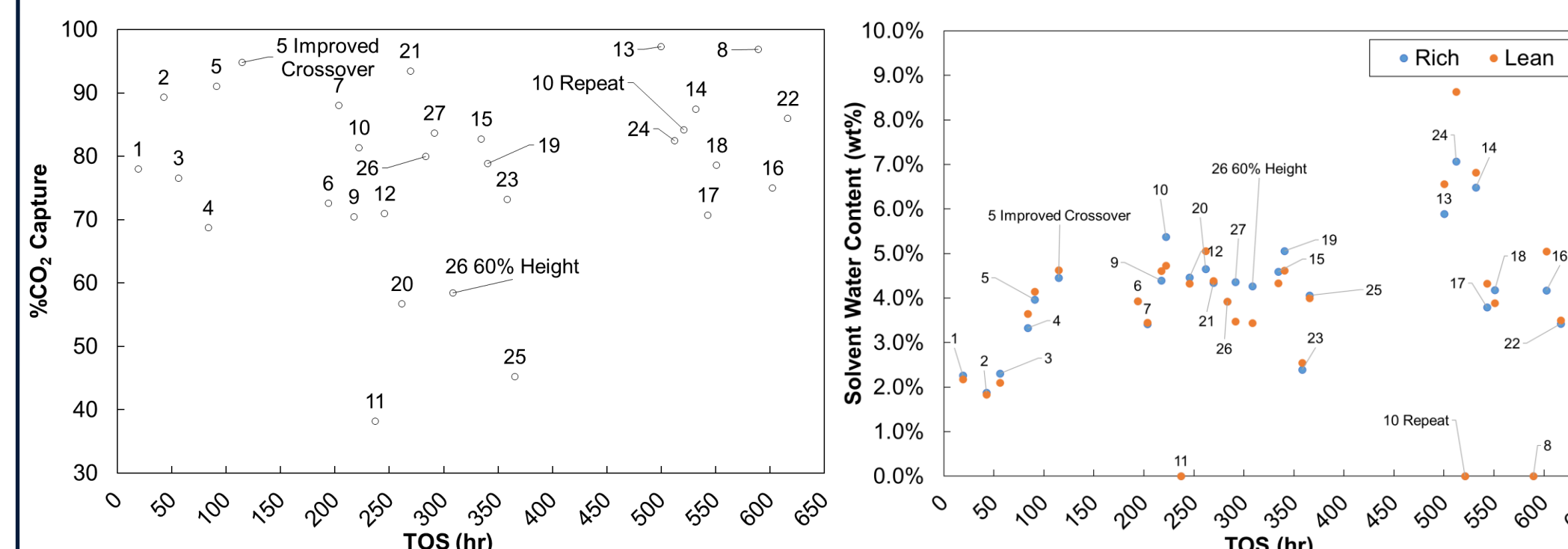
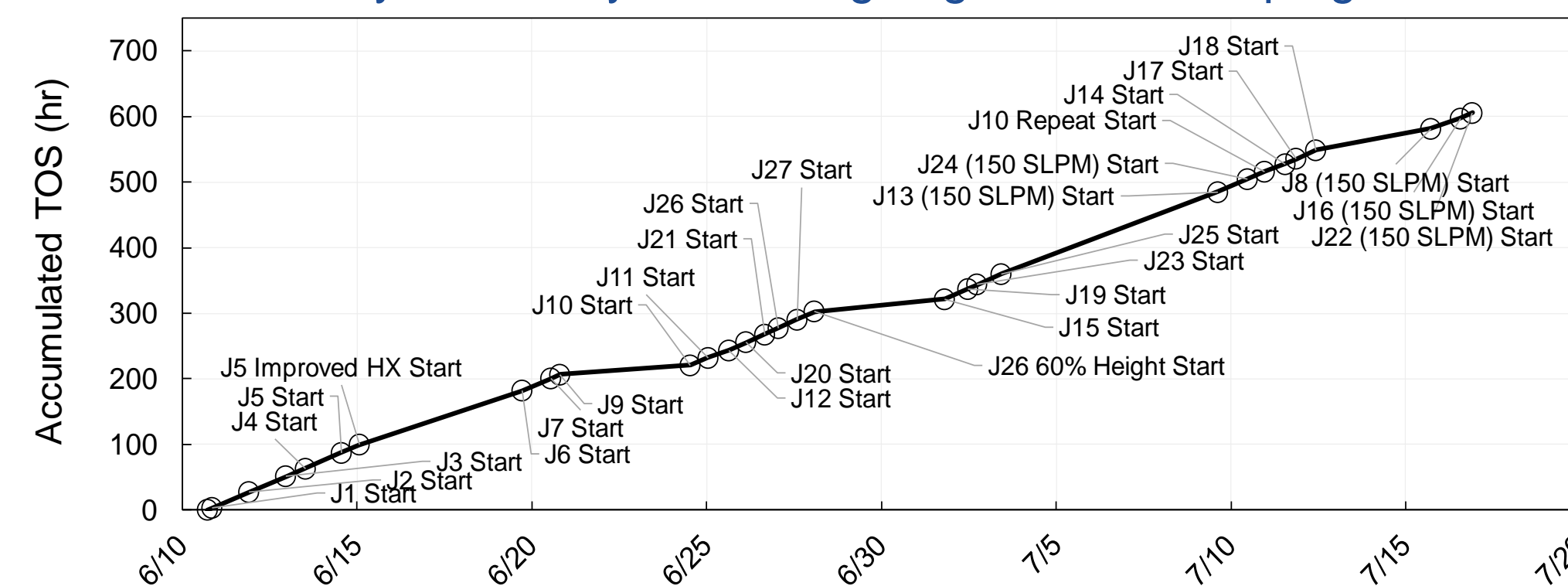
- Campaign with 580 hr with the chosen formulation
- >99% CO₂ capture (essentially *negative emission*) achieved under specific operational condition
- Water balance controlled between 1-3 %
- <10 ppm amine emission detected coming out of water wash outlet

RTI Bench-scale Gas Absorption System (BsGAS)



- Accommodates 50-60 L of solvent; 0.1 tpd CO₂ equivalent
- Equipped with conventional absorber/RPB, convention regenerator/ 2stage flashes (2SF), and 2 separate wash sections
- Conventional absorber has 3 interstage coolers (ICs). Conventional regenerator has 3 interstage heaters (IHs)
- Simulated FG used with varying CO₂/H₂O/O₂ content
- Closed-loop chill water for cooling, small steam boiler provides steam for heating
- Online FTIR analyzer and CO₂ sensors for gas monitoring

Key Takeaways from Ongoing BsGAS Campaign



- >620 hr of continuous TOS on BsGAS system achieving capture rates of 97%
- Measured SRD: 2.5-5 MJ/kg-CO₂
- Low emissions and low oxidative degradation
- Water content balanced and controlled at 2-7%

Techno-Economic Analysis (TEA)

- The NETL's baseline rev. 4a issued on September 2019 used for cost comparison
- Cost savings comes from the reduced CAPEX from using the PIP and RPB
- GEN2NAS shows 41-44% reduction in the cost of capture, compared to DOE's baseline case B31B

	B31B.97 Sep 2019	B31B.97 Oct 2022	B31B.97-RTI NAS Oct 2022	GEN2NAS w/PIP	GEN2NAS w/RPB
CAPEX					
Total Plant Cost (TPC), 2018\$/kW	\$1,281	\$1,117	\$1,006	\$907	\$880
Total As Spent Capital (TASC), \$/1,000	\$1,701	\$1,483	\$1,368	\$1,238	\$1,203
OPEX, MM/yr (100% Capacity Factor Basis)					
Fixed Operating Cost	\$41.3	\$36.4	\$31.6	\$28.9	\$28.1
Variable Operating Cost, Less Fuel	\$31.9	\$23.5	\$21.4	\$23.1	\$22.3
NG Fuel	\$179.0	\$179.0	\$179.0	\$179.0	\$179.0
Total OPEX	\$252.1	\$239.0	\$232.1	\$231.0	\$229.5
Plant Output					
Net Power Output, Mwe	646	637	635	635	635
MWh	5,658,960	5,580,120	5,565,535	5,565,535	5,565,535
Common Factors Used for COE Calculation					
Fixed Charge Rate (FCR)	0.0707	0.0707	0.0707	0.0707	0.0707
Capacity Factor (CF)	0.85	0.85	0.85	0.85	0.85
COE, excluding CO ₂ TS&M, millions/kWh	70.9	66.1	63.2	60.9	60.1
COE, including CO ₂ TS&M, millions/kWh	74.3	69.9	66.9	64.7	63.9
CO₂ Capture					
CO ₂ Capture Product, tonne/hr (metric)	223.78	241.18	241.08	241.08	241.08
Total Carbon Captured	90.0%	97.0%	97.0%	97.0%	97.0%
Costs of CO ₂ Captured (\$/tonne)	79.6	60.2	52.3	46.5	44.3
Costs of CO ₂ Captured (\$/tonne) with TS&M	89.6	70.2	62.3	56.5	54.3
COE Breakdown (millions/kWh)					
CAPEX	25.0	22.1	20.4	18.5	18.0
Fixed O&M	8.6	7.7	6.7	6.1	5.9
Variable O&M	5.6	4.2	3.9	4.2	4.0
Fuel	31.6	32.1	32.2	32.2	32.2
CO ₂ T&S	3.5	3.8	3.8	3.8	3.8
Total	74.3	69.9	66.9	64.7	63.9
Reference Plant					
COE, excluding CO ₂ TS&M, millions/kWh	43.30	43.30	43.30	43.30	43.30
Cost of CO ₂ T&S (\$/tonne)	10.0	10.0	10.0	10.0	10.0

Thermal and Oxidative Degradation of GEN2NAS

- The formulation is stable at 120 °C for 6 weeks under ambient CO₂ pressure, as analyzed by GC and NMR spectroscopy
- Formation of aldehyde derivative of the amine, along with some other oxidized derivatives are degradation products in the presence of air
- The effect of NO_x on the formulation is currently being investigated

Ongoing/ Future Work

- Measurement of various physical properties of the GEN2NAS formulation
- BsGAS testing with rotating packed bed absorber configuration
- Determination optimal run condition
- Finalize TEA

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More Information

*Presenting author: Moumita Bhattacharya
919.485.1089
moumitab@rti.org
www.rti.org

