SRI International

2019 NETL CO_2 Capture Technology Project Review Meeting

Mixed-Salt Based Transformational Solvent Technology for CO_2 Capture

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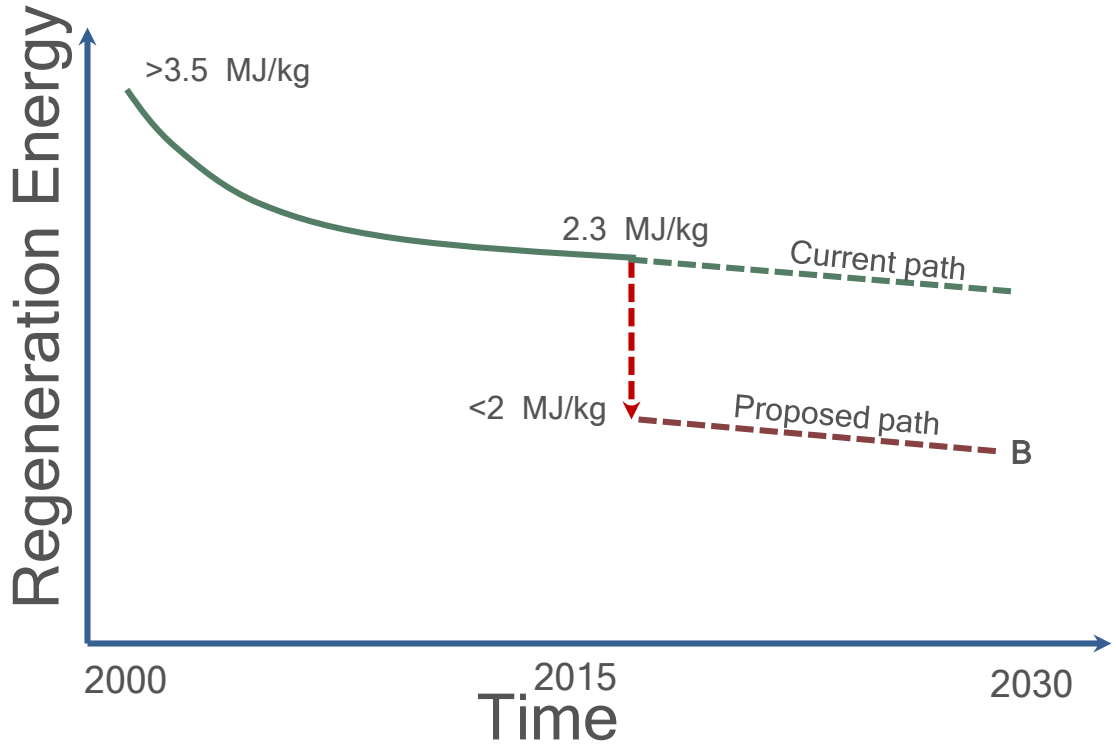
Presentation Outline

- Technology Background
  - Needs to reduce CO_2 capture costs
  - Advanced Mixed-Salt Process
  - Process Benefits
- Project Structure
  - Objectives and Budget
  - Project Team and Organization
  - Development Path
  - Project Tasks
  - Available Resources
- Project Status and Test Results Update
- Acknowledgements

Reducing Capture Costs Beyond the Current Values

New transformational technologies

-A step reduction of the regeneration energy is required



- Low regeneration energy by solvent pairing
- Energy recovery by heat integration

Pathway to reach DOE 2030 CO_2 capture goals

Advanced Mixed-Salt Process Details

How it works:

Selected composition of potassium carbonate , ammonium salts and an additive

- Overall heat of reaction 35 to 60 kJ/mol (tunable)

Absorber operation at 20° - 40° C at 1 atm

Regenerator operation at 90° - 120° C at ~10 atm

- Produce high-pressure CO_2 stream

K_2CO_3–NH_3–Additive-CO_2–H_2O system

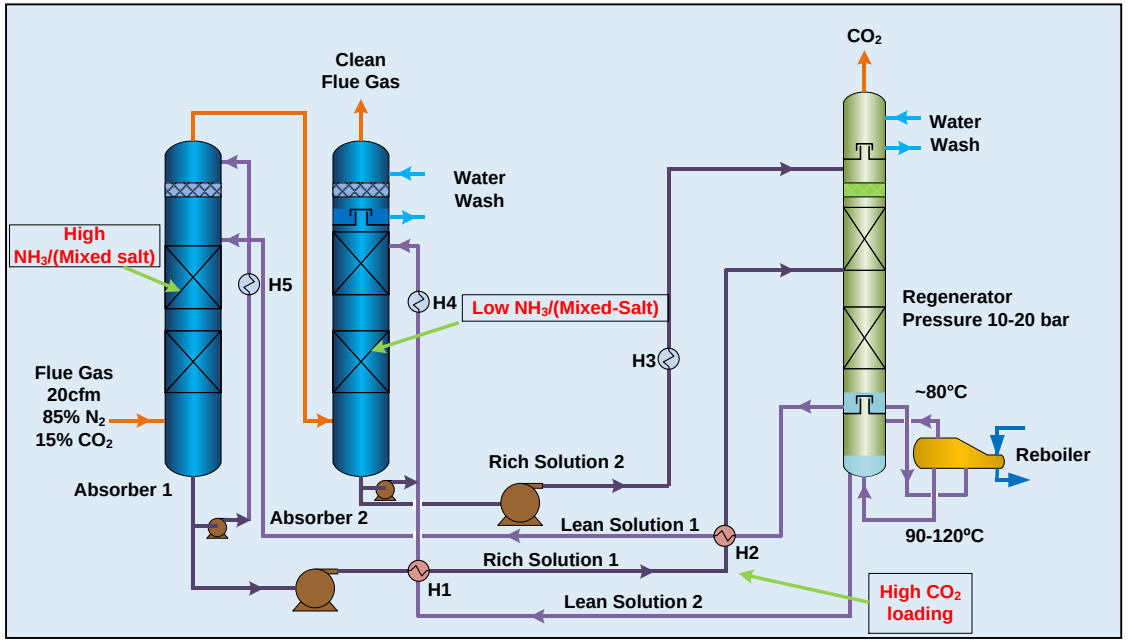
High CO_2 cycling capacity

Reduced Ammonia Emission

Reduced Reboiler duty

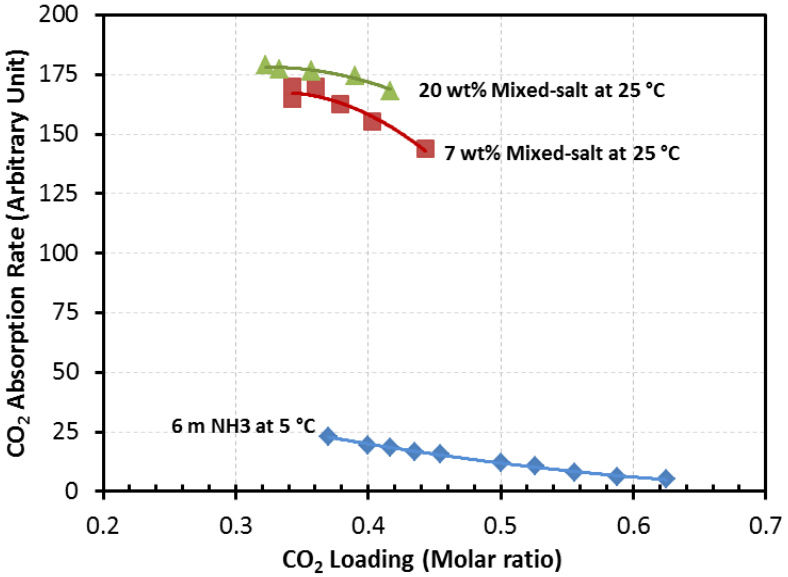
Reduced CO_2 Compression Energy

A significant step change for reaching DOE's reduced CO_2 capture cost targets.



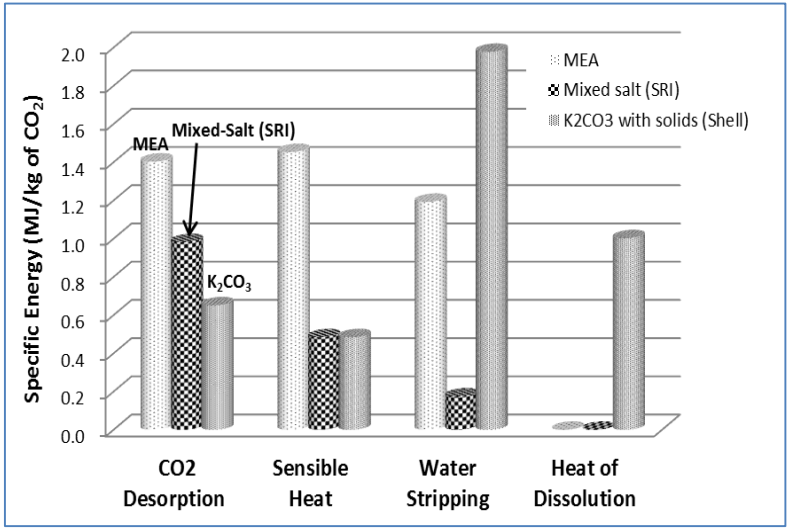
Process Enhancements

Enhanced Kinetics at High Temperature



Observed rate enhancement of CO_2 absorption efficiency by comparison of mixed-salt with NH_3

Low Energy Requirement for CO_2 Stripping



Estimated regenerator heat requirement for mixed-salt system with 0.2 to 0.6 cyclic CO_2 loading. Comparison with neat K_2CO_3 and MEA is shown

(Source for the Shell K_2CO_3 process, Schoon and van Straelen, 2011).

Absorber side: Reduced packing height
Regenerator side: Reduced water evaporation

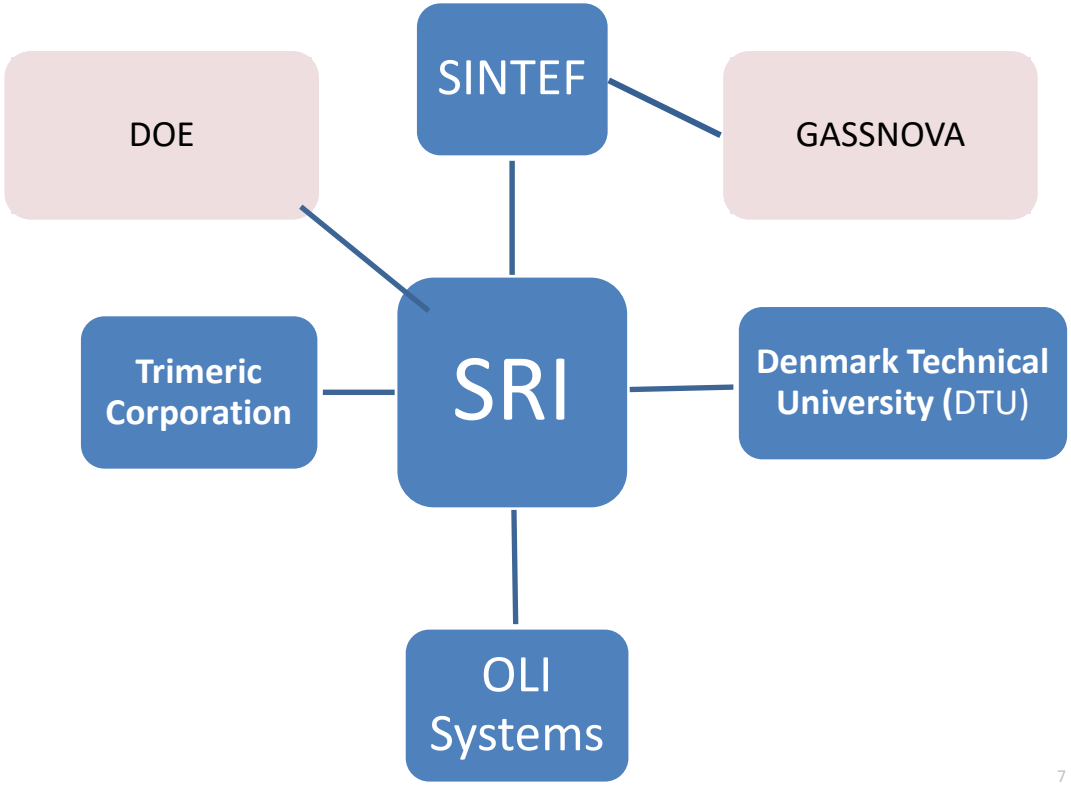
Project Objectives, Budget and Period of Performance

- Project Objectives
  - High CO_2 loading capacity
  - Solvent rich system
  - Potential to reach DOE cost target \$30/ton CO_2 by 2030
- Period of Performance: 6/1/2018 to 11/30/2021
- Project budget (Contract No: DE-FE0031597)
  - DOE Funding: \$3,105,797
  - Partner Share: \$951,897

Project Team

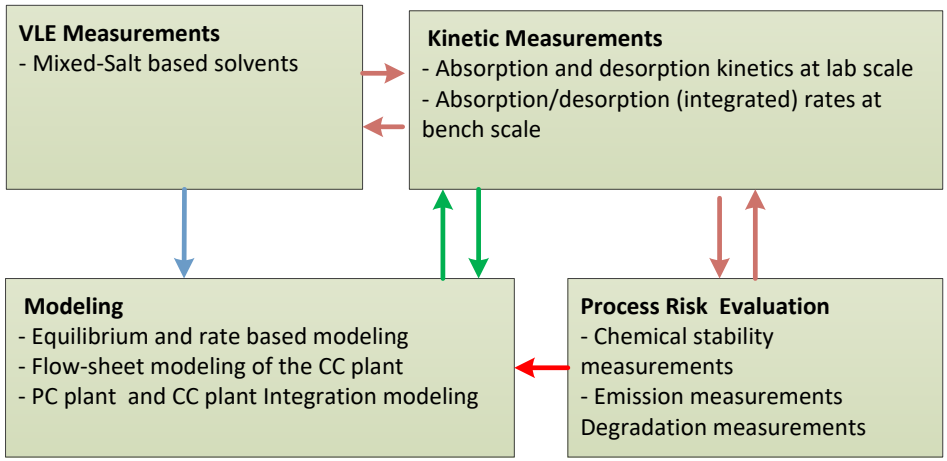
Mixed-Salt Based Transformational Solvent Technology for CO_2 Capture

Project Manager: Andrew Jones, NETL
Prime Contractor: SRI International
Project Team: US and International Partners



Opportunities for US-Norway Collaborations leading to new IP and new markets

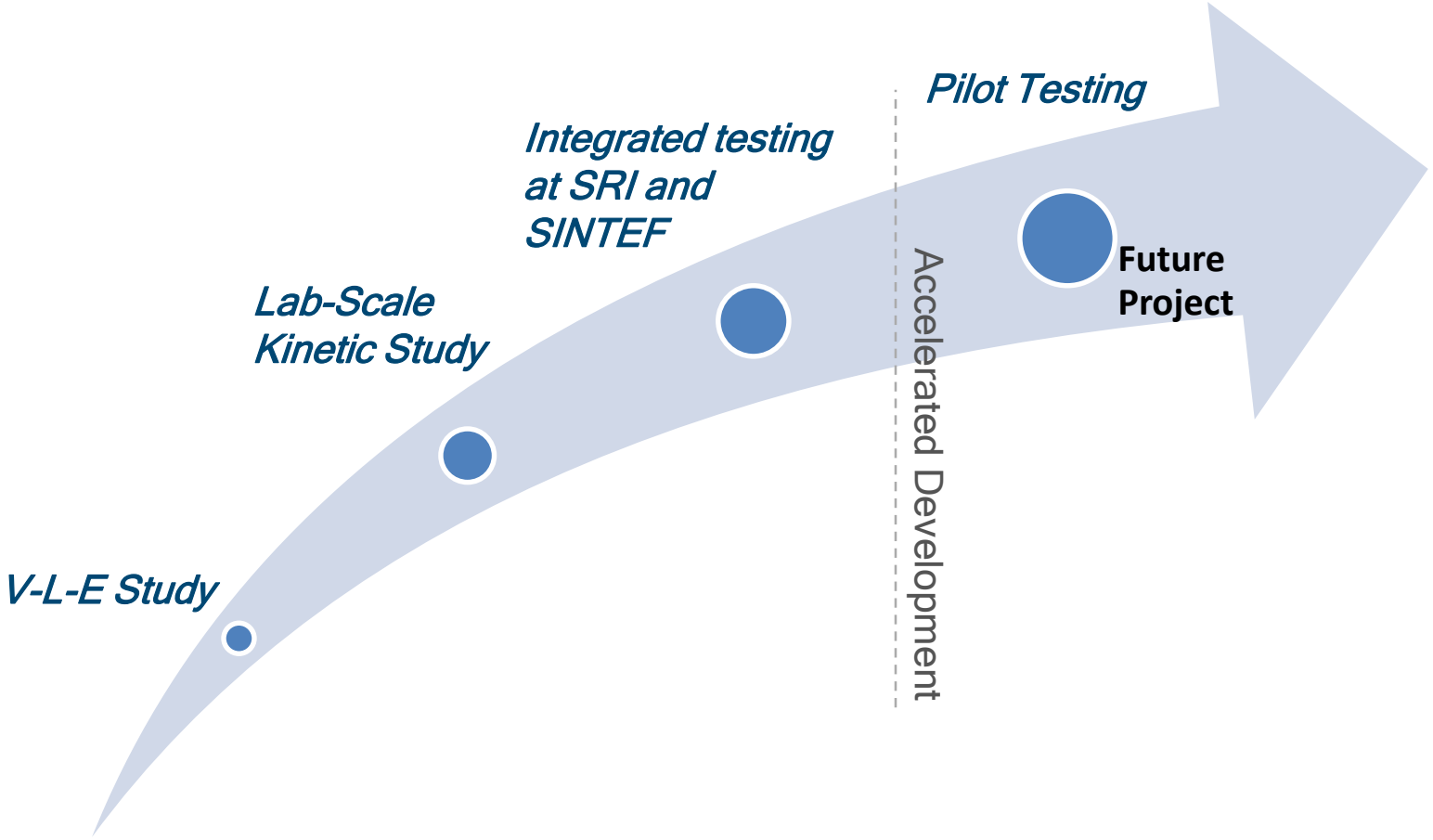
Work Organization



- SRI International, USA
  - Advanced mixed-salt composition development and testing
- DTU, Denmark (Cost-share partner)
  - VLE Measurements & Thermodynamic modeling
- OLI Systems, USA
  - Flowsheet Model Design (energy and mass balance)
- Trimeric, Corp., USA
  - Process Techno Economic Analysis
- SINTEF, Norway (Cost-share partner)
  - Emission and degradation studies
  - Alternative Mixed-salt composition development and testing

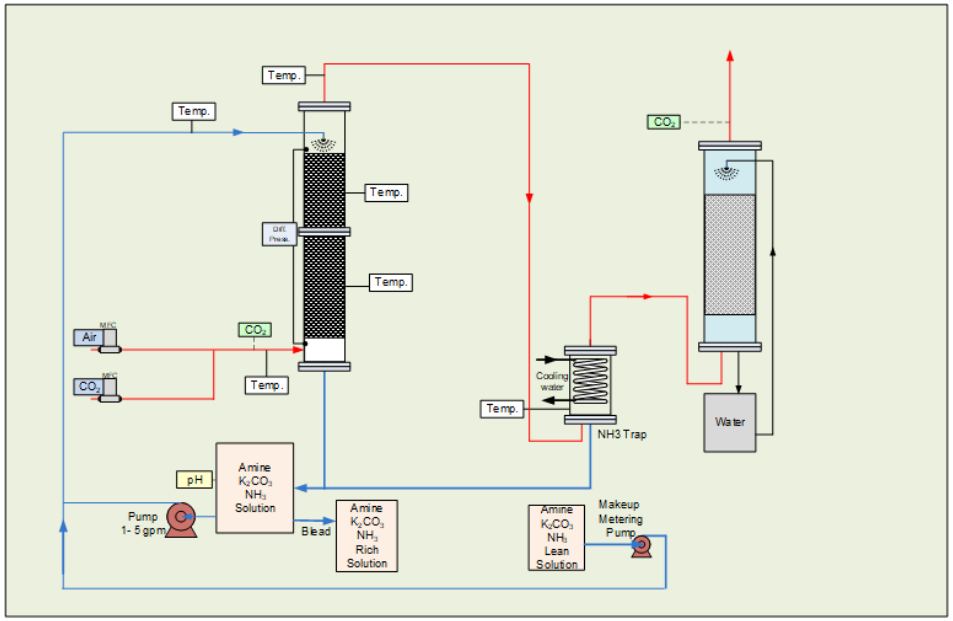
Mixed-Salt Based Transformational Solvent Technology for CO_2 Capture

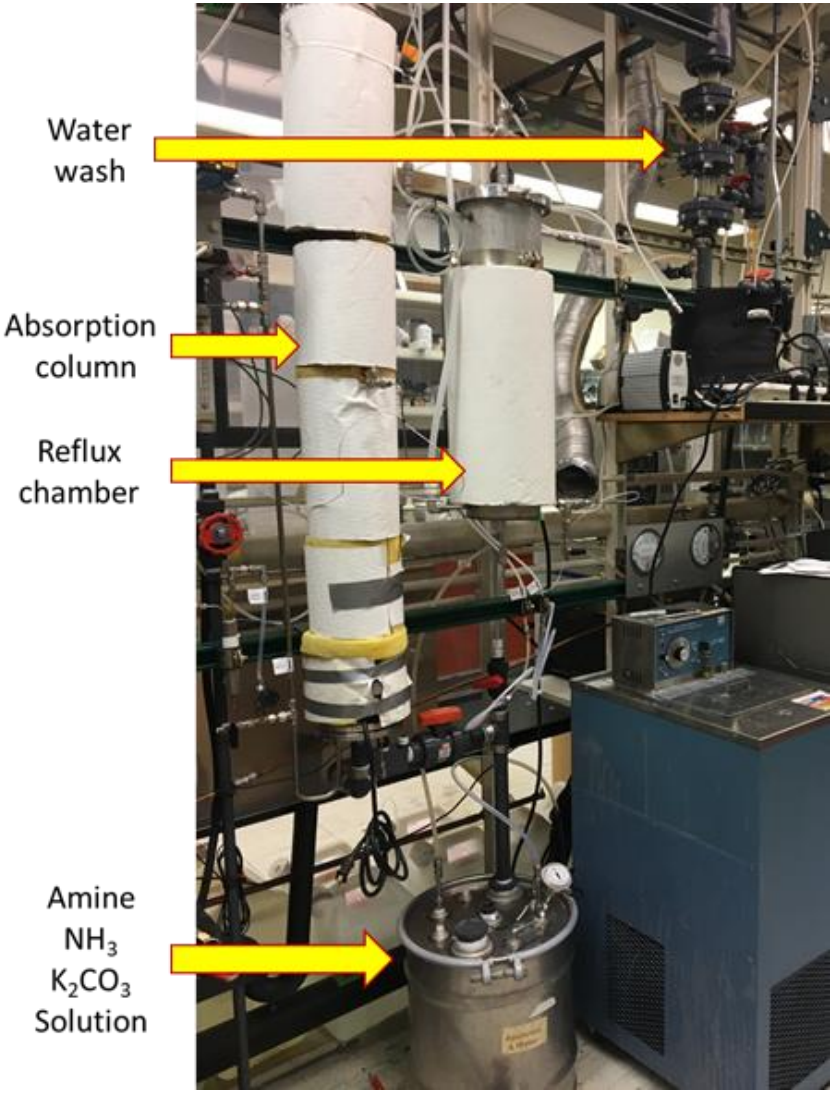
Team : SRI (USA), SINTEF (Norway), OLI (USA), DTU (Denmark), Trimeric (USA)
Funding : US DOE (SRI Project) & CLIMIT (SINTEF Project)



Opportunities for reducing CO_2 from small and large-scale applications

Small bench scale absorber system for AMSP testing



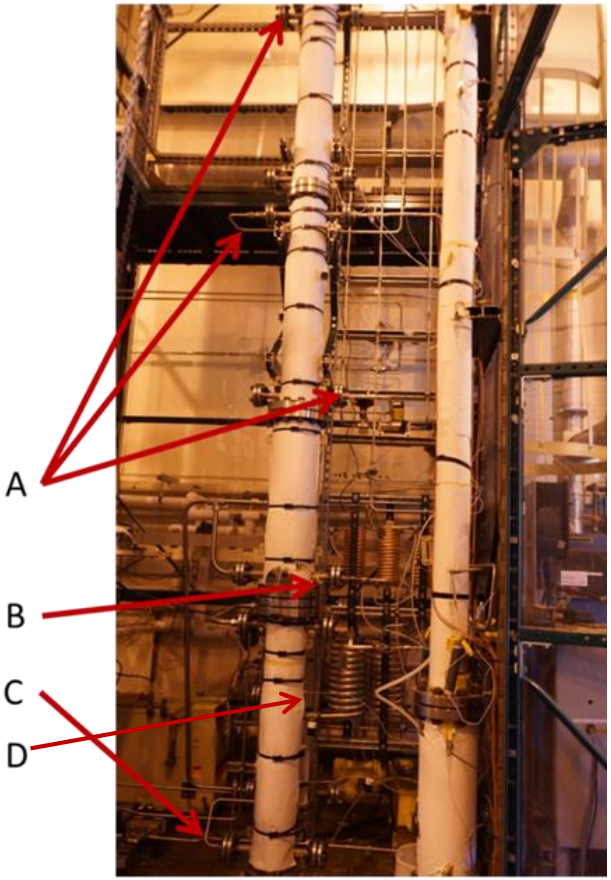


Existing Infrastructure for Testing

Photographs of large bench scale setup

Lab scale system

Large bench scale system



A: Rich solution inlet locations
B: Discharge locations for high NH_3/K solution
C: Discharge locations for low NH_3/K solution
D: Heat exchangers (Cold rich↔ Hot lean)

Project Tasks

BP1: 24 months BP2: 12months

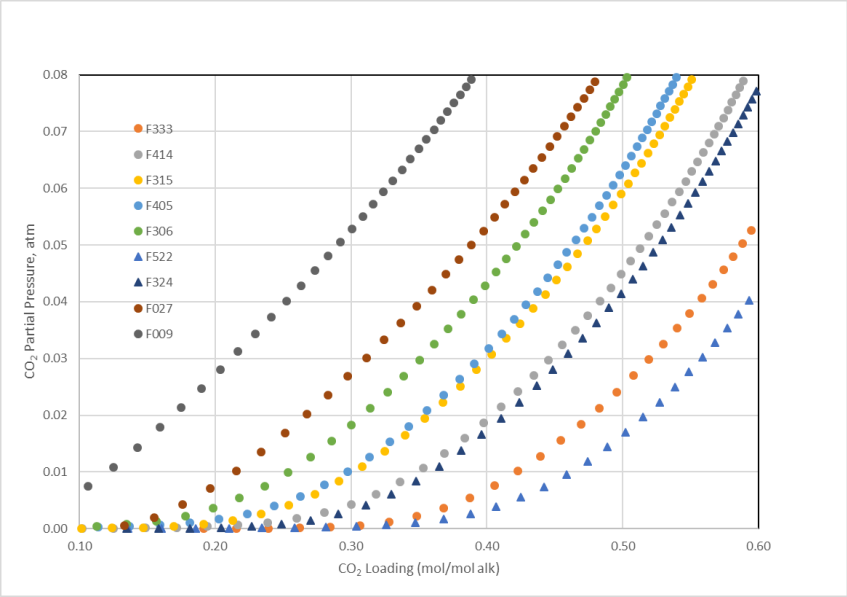
- Task 1: Project Management and Planning (SRI)
- Task 2: Vapor-Liquid-Equilibria Measurements (DTU)
- Task 3: Process Kinetic Assessment (SRI)
- Task 4: Emission and Degradation Measurements (SINTEF)
  - Subtasks 4.1 and 4.2: Emission and thermal degradation measurements
  - Subtask 4.3; Integrated testing with amines and mixed-salt blends
- Task 5: Rate-Based Model Development (OLI)
- Task 6: Preliminary Techno-economic Analysis (Trimeric)
- Task 7: Integrated System Testing (SRI)
- Task 8: Process Flowsheet Model Development (OLI)
- Task 9: Techno-economic Analysis (Trimeric)

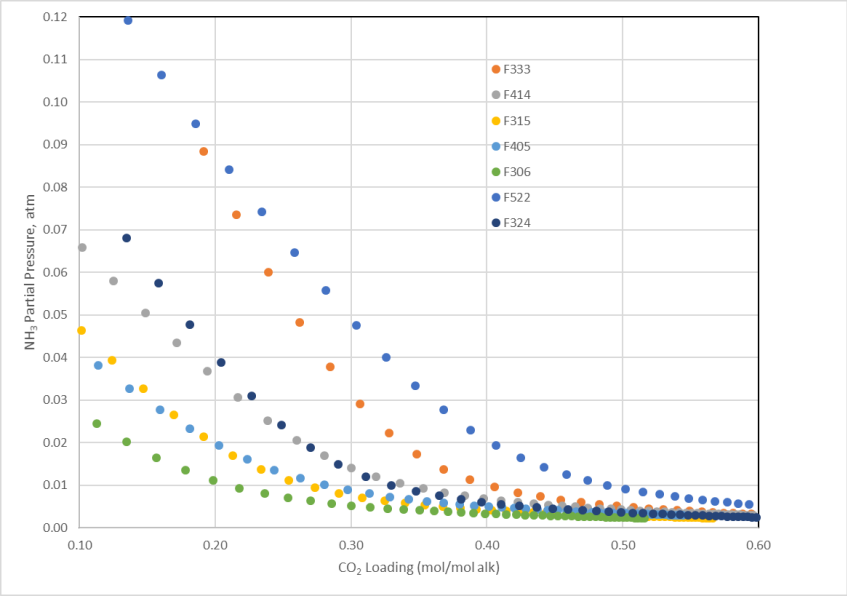
*** Tasks in Red will be performed in BP2**

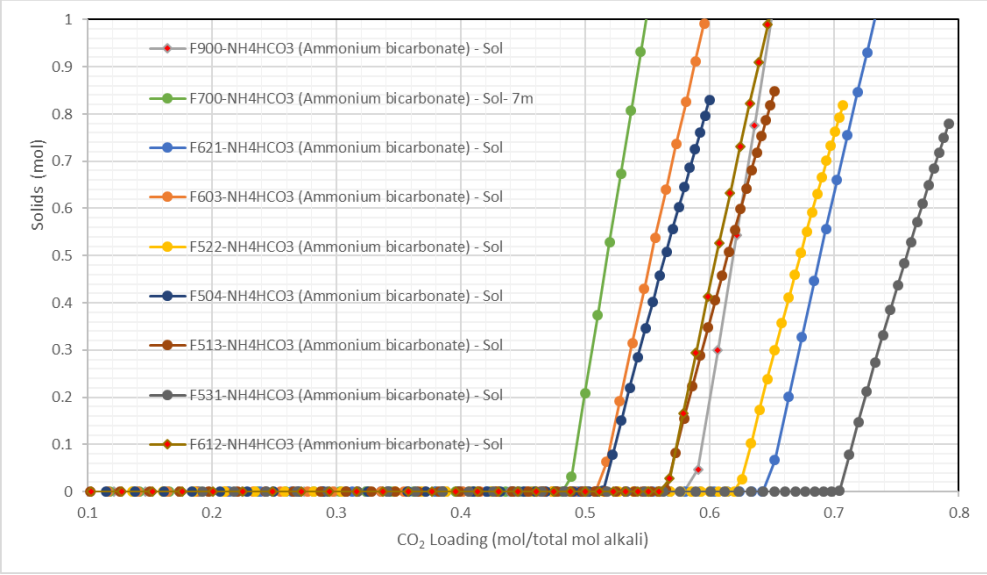
BP1 Project Status Update

As of 7/31/2019	Status
Task 1- Project Management and Planning	On going
Task. 2.0- VLE Measurements at DTU	
Subcontract award to DTU	Completed
VLE measurements	In Progress
Task 3.0 - Kinetic Measurements at SRI	
Bench-scale set-up test plan development	completed
Bench-scale testing	In progress
Task 4.0 – New amine Development and Emission Assessment	
Technology transfer and cost-share agreement to SINTEF	completed
Information exchange	In progress
Task 5.0 – Process Modeling	
Subcontract award to OLI	Completed
Flow-sheet modeling	In progress
Task 6.0 – Preliminary Technoeconomic Analysis (TEA)	
Subcontract award Trimeric	Completed
Preliminary TEA	To begin in November

VLE Modeling at SRI

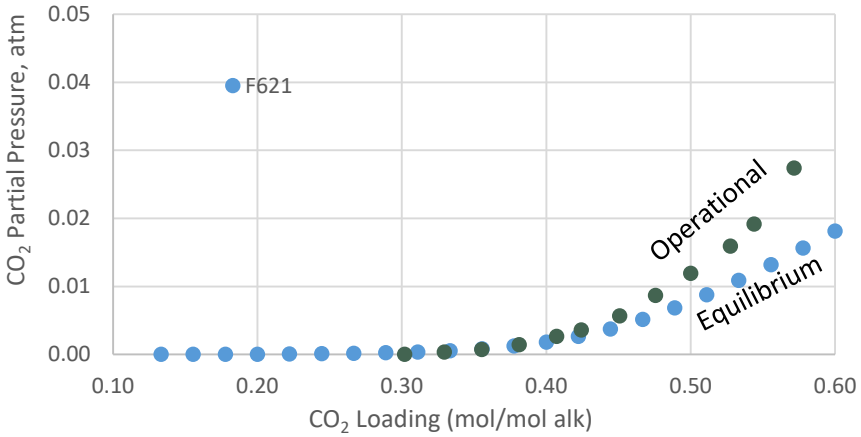






Testing at SRI

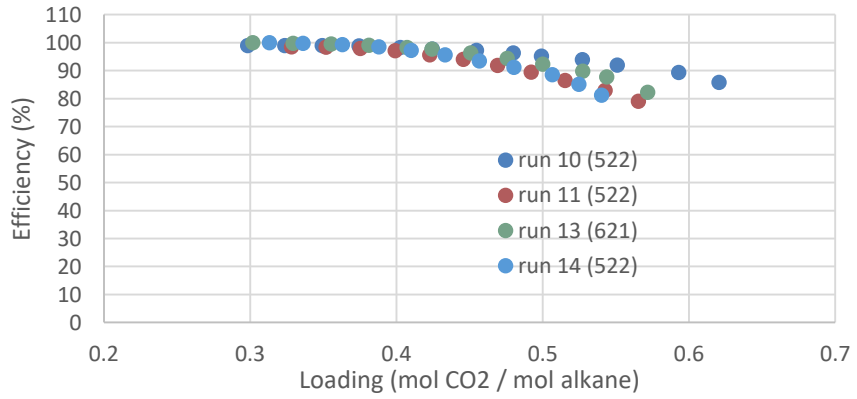
Comparison of test data with and modeling



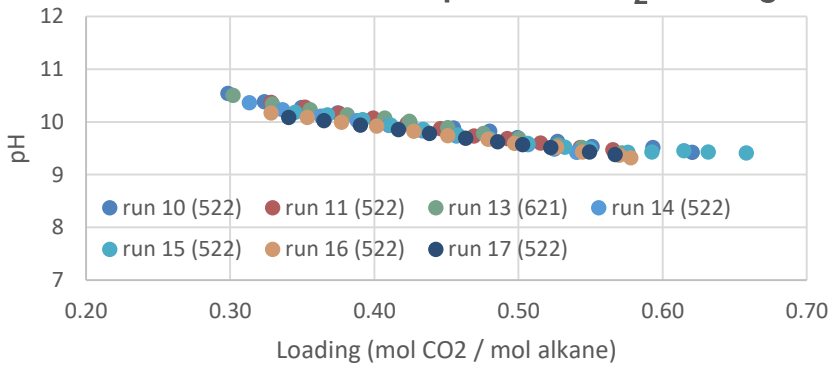
Run Table

Run #	Composition	Temperature (℃)	Gas flow (SLPM)	CO_2 loading (initial)	CO2 loading (final)	Concentration (m)
1	420	24 <=> 31 °C	32.5	0.24	0.52	6
2	520	29 ±1°C	17	0.22	0.36	6
3	52(0.5)	28 <=> 33 °C	20.5	0.14	0.42	7.2
4	521	24 <=> 28 °C	21	0.16	0.5	7.1
5	522 (air only, no CO2)	n/a	n/a	n/a	n/a	n/a
6	522 (continue from run 5)	21 ±1°C	10	0.15	0.31	8
7	522	21 ±1°C	10.4	0.13	0.3	8.6
8	522 (continue from run 7)	21	4 to 40	0.34	0.53	8
9	622	21 ±1°C	4 to 40	0.11	0.41	8.6
10	522	20	10 <=> 11	0.3	0.62	8.75
11	522	20	10 <=> 11	0.33	0.565	8.67
12	11-cont.	n/a	n/a	n/a	n/a	n/a
13	621	20.5 ±0.5°C	10.0 <=> 10.7	0.3	0.57	8.475
14	522	16 <=> 20 °C	9.9 <=> 10.7	0.31	0.54	8.65
15	522	20 °C	10	0.35	0.65	8.9
16	522	22.5 °C	10	0.33	0.58	9
17	522	25.5 °C	10	0.34	0.57	8.7
18	621	20	10	0.4		9
19	423	20	10	0.4		9

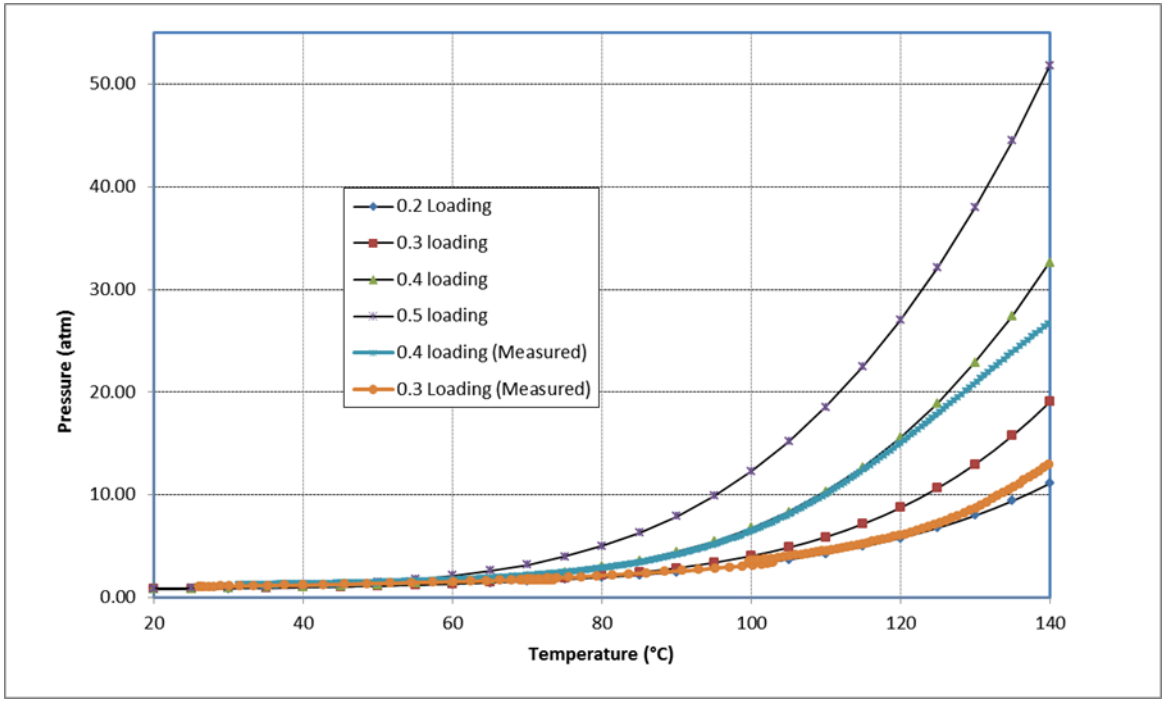
Effect of CO_2 loading on efficiency



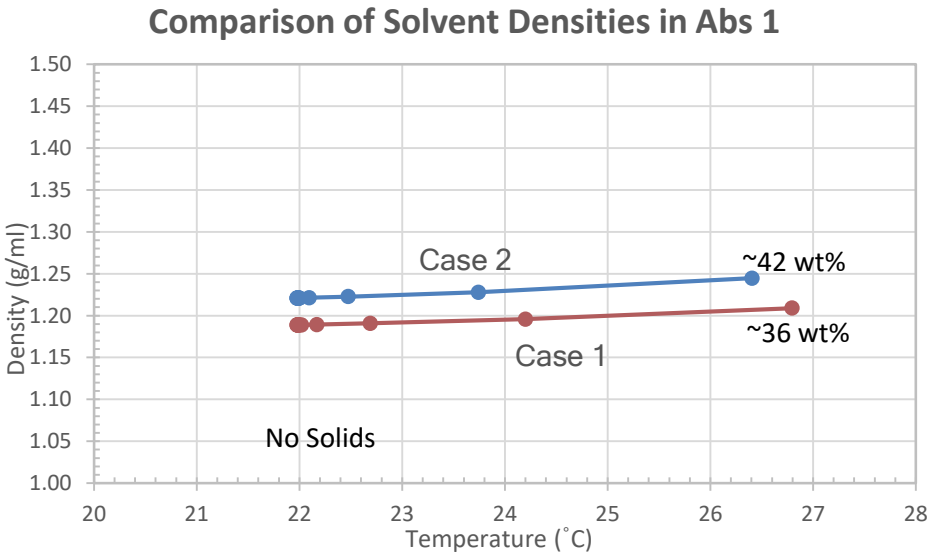
Correlation between pH with CO_2 loading

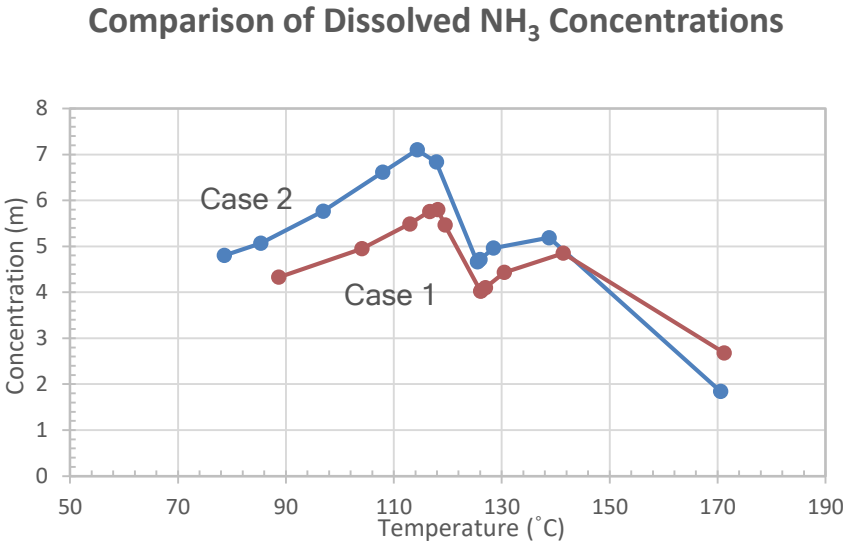


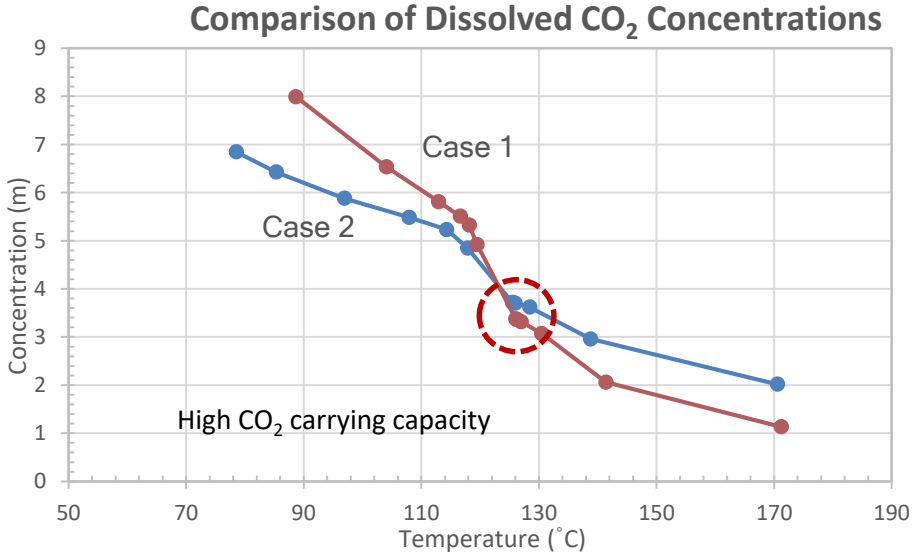
Measured and calculated system pressure of 0.2 to 0.5 CO_2 loaded AMSP solutions with temperature

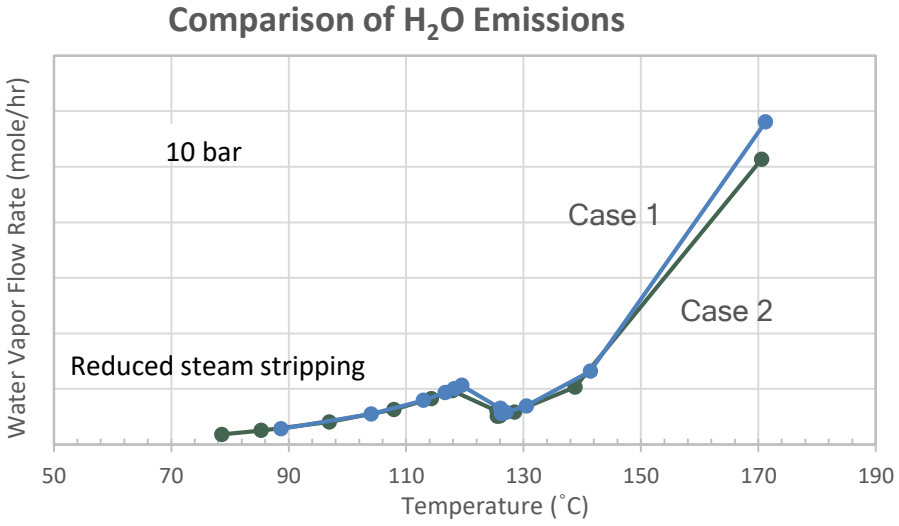


Process Modeling at OLI









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- Trimeric Corporation (Andrew Sexton)

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Thank You

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