Development and Bench-Scale Testing of a Novel Biphasic Solvent-Enabled Absorption Process for Post-Combustion Carbon Capture (DE-FE0031600)

Project Kickoff Meeting

Presenter: Yongqi Lu

Illinois State Geological Survey

Pittsburgh, PA · May 10, 2018

Project Team and Key Personnel

- University of Illinois:
  Illinois State Geological Survey
  - David Ruhter (MS, Lab Manager)
  - Hafiz Salih (PhD, Environmental Engineer)
  - Hong Lu (PhD, Chemical Engineer)
  - Qing Ye (Post-Doctoral Research Fellow)
  - Varenya Mehta (MS, Environmental Engineer)
  - Yang Du (PhD, Chemical Engineer)
  - Yongqi Lu (PhD, Chemical/Environmental Engineer)

  Illinois Sustainable Technology Center
  - BK Sharma (PhD, Senior Chemical Engineer)
  - Kevin O’Brien (PhD, Director)
  - Wei Zheng (PhD, Senior Chemist)

- Trimeric Corporation:
  - Darshan Sachde (PhD, Senior Chemical Engineer)
  - Katherine Dombrowski (Principal Technical Staff)
  - Kevin Fisher (VP, P.E., Principal Engineer)
  - Ray McKaskle (P.E., Principal Engineer)

Objectives

- Advance the development of a transformational biphasic CO_2 absorption technology from lab- to bench-scale

- Design, fabricate and test a 40 kWe bench-scale capture unit with simulated and actual coal flue gas

- Demonstrate the technology progressing toward achieving the DOE's Transformational Capture goals

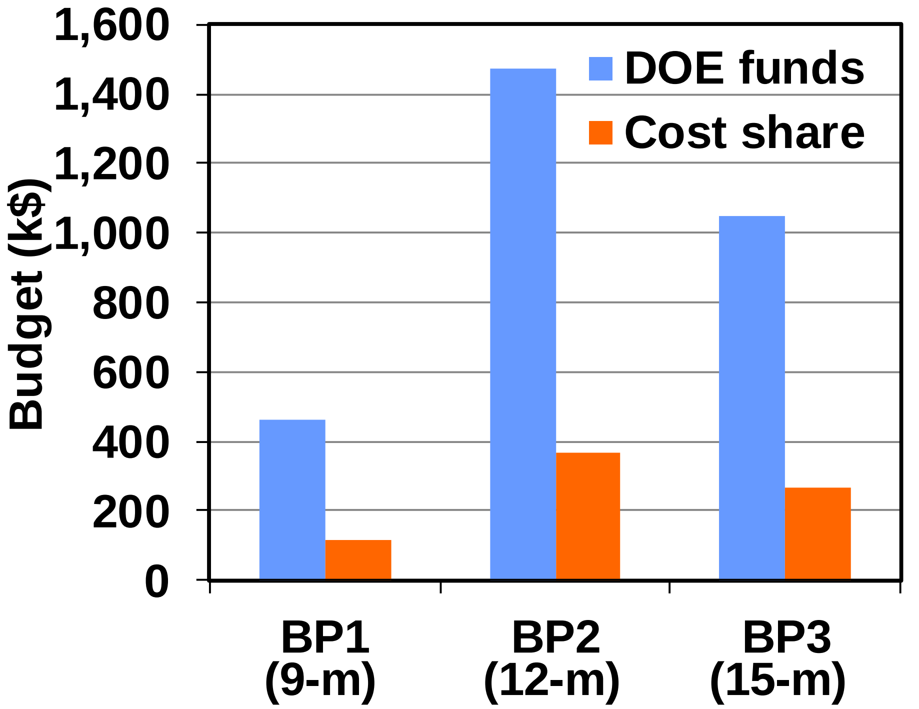
Budget Profile and Duration

Project duration: 36 mon, 3 Budget Periods (4/6/18–4/5/21)

- BP1: 9 mon (4/6/18-1/5/19)
- BP2: 12 mon (1/6/19-1/5/20)
- BP3: 15 mon (1/6/20-4/5/21)

Funding Profile:

- DOE funding of $2,981,779
- Cost share (in-kind) of $750,051 (20.1%)



Technical Background

Project Task Flow and Organization

Scope of Work and Approaches

Project Timeline and Milestones

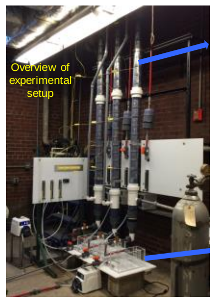
Plan for Future Scale-Up /Development

Progression of Technology Development

Currently

Proof-of-Concept
Funding: *UI (Part of Dissertation Research, 2013-2015)*

Solvent study, Laboratory



10 kWe Test, Laboratory

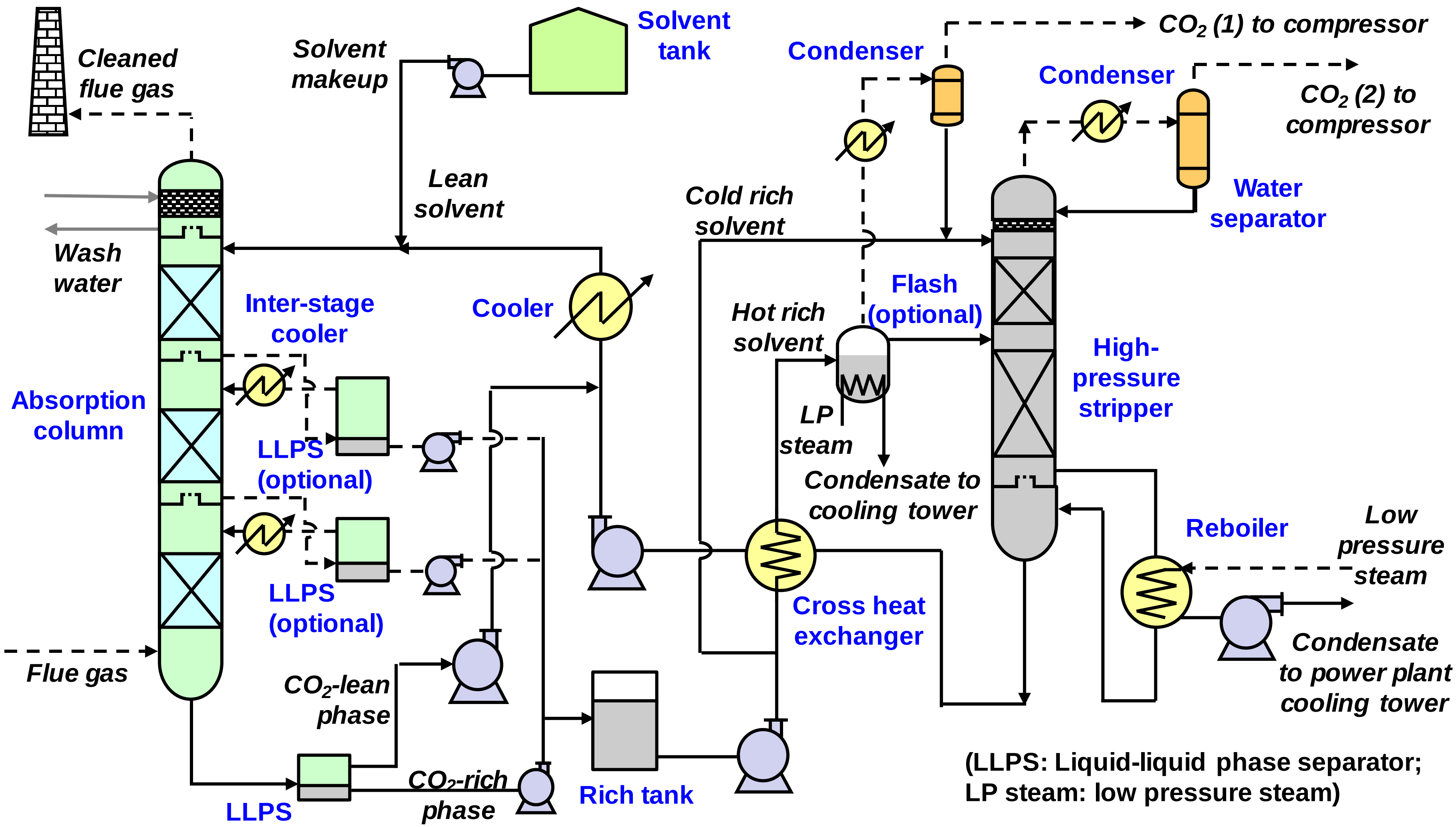
Separate Absorber / Stripper
Funding: *DOE / UI (2015-2018)*

40 kWe Test, Laboratory & Power Plant Slipstream

Bench Scale Closed-Loop Unit
Funding: *DOE / UI (2018-2021)*

Future Scale-Up Development

Biphasic CO_2 Absorption Process (BiCAP)



(LLPS: Liquid-liquid phase separator;
LP steam: low pressure steam)

Current Status of Solvent and Process R&D

Solvent Development	Results	Status
~80 solvents screened	2 solvents selected	Completed
Vapor-liquid equilibria (VLE)	Measured at both absorption & desorption conditions	Completed
Absorption kinetics	Measured under full ranges of CO_2 loadings	Completed
Oxidation and thermal stabilities	Thermal stability at 150°C = MEA at 120°C; Oxidation degradation ~8 times < MEA	Completed
Viscosity	CO_2-saturated rich phase solutions < 50 cP	Completed
CO_2 enrichment /phase transition	≥98% of total CO_2 uptake enriched in <50% of original solution	Completed
Heat of desorption	Estimated with VLE data	Completed
Corrosion effect	Less corrosion than MEA on CS or SS	Completed
Volatility	N/A	Not studied

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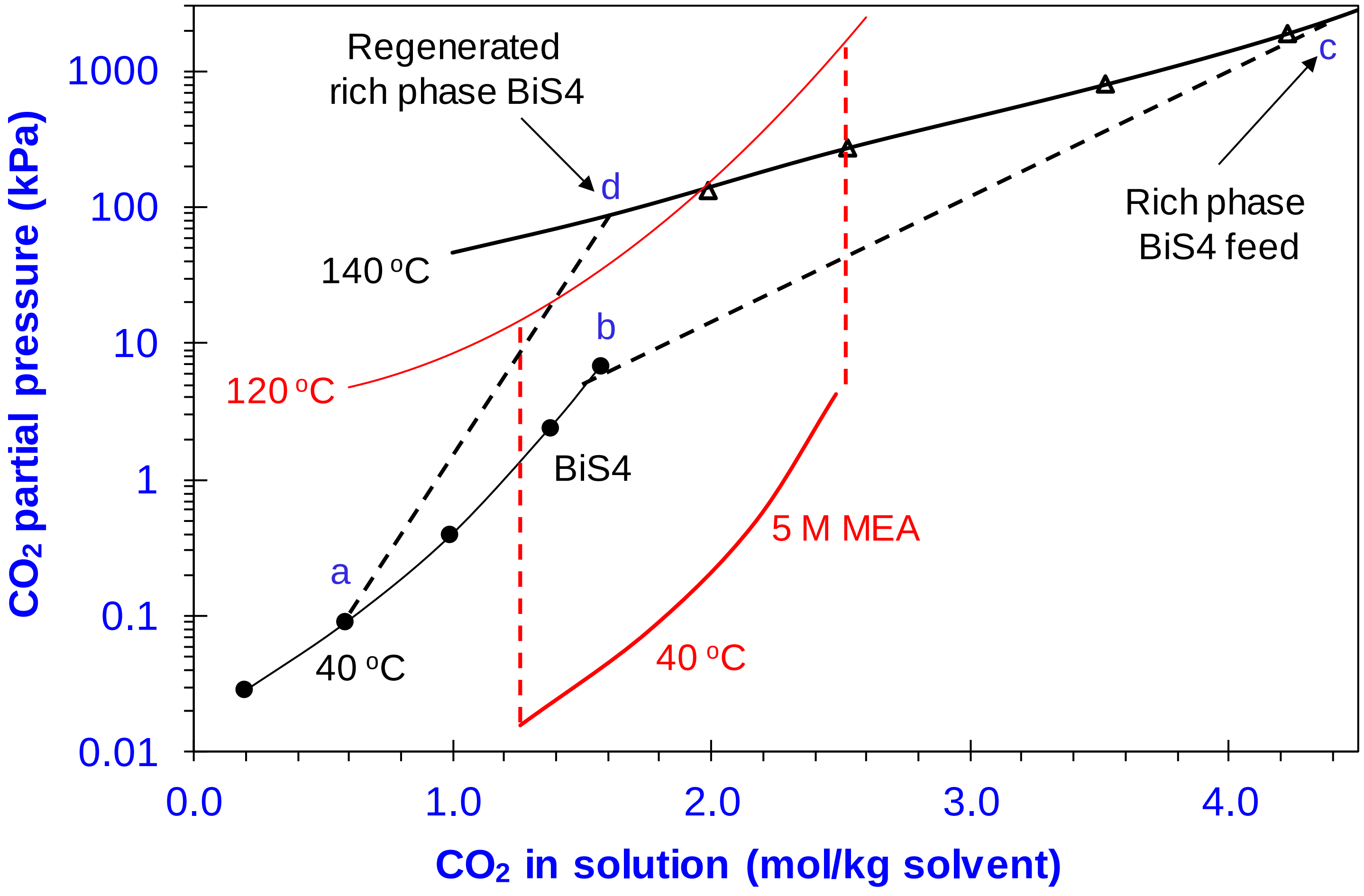
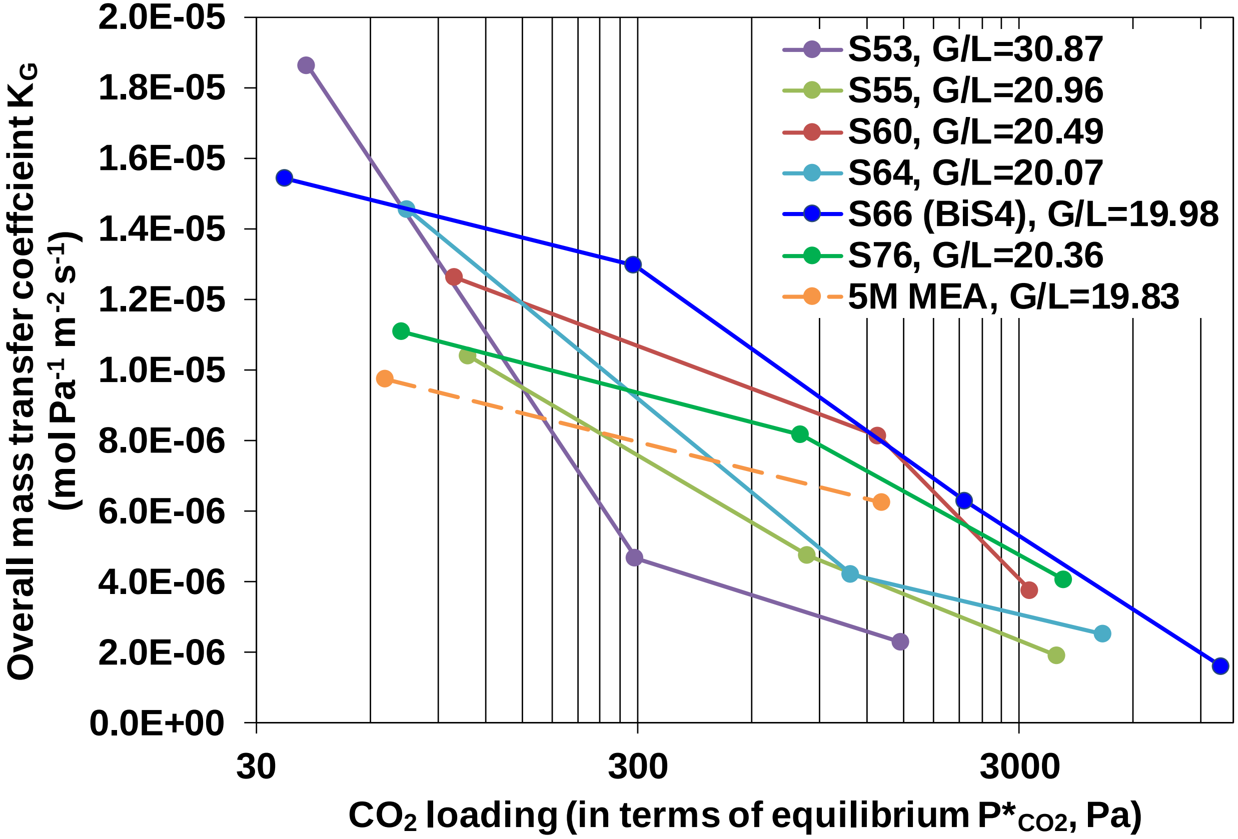
Process Development	Results	Status
CO_2 absorption coupled with multiple stages of phase separation	Process concept demonstrated by successful operation on a lab 10 kWe absorption column; Faster rates of selected biphasic solvents than MEA demonstrated in column testing	Completed
CO_2 flash and stripping desorption process	Process concept being tested on a lab 10 kWe desorption system; MEA tests completed with successful operation; Biphasic solvents under testing now	Ongoing
Process model	Rigorous rate-based Aspen Plus® process simulation model developed for one biphasic solvent	Completed for 1 solvent
Solvent emission control process options	N/A	Not studied
Solvent reclamation process options	N/A	Not studied

VLE of Biphasic Solvents vs. MEA



- Absorption step: working capacity of BiS4 similar to that of MEA
- Desorption step: working capacity of BiS4 double that of MEA

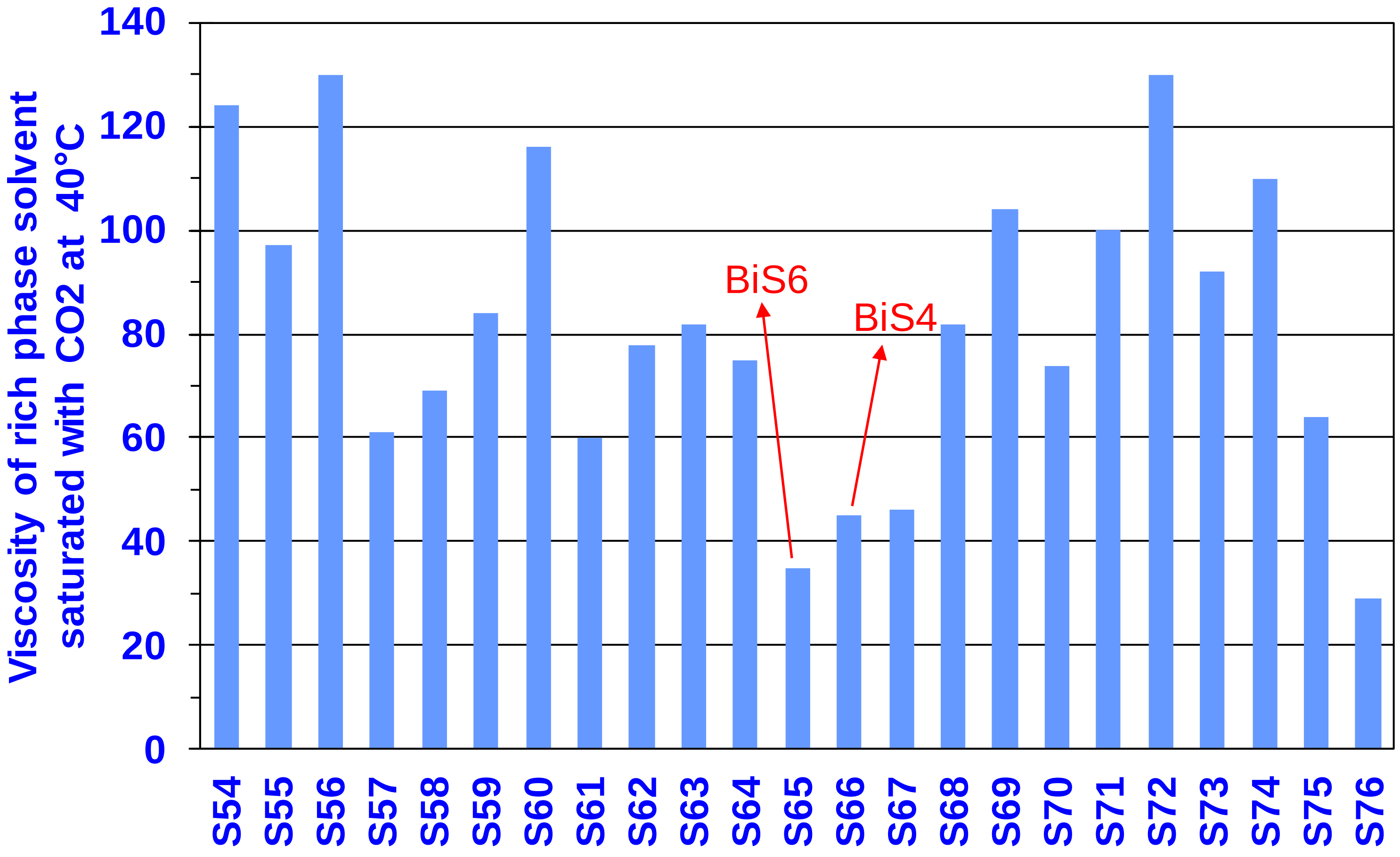
Absorption Rates of Biphasic Solvents vs. MEA



Example biphasic solvents at CO_2 loadings over $P^*_{CO_2}$ = 0.03–5 kPa at 40°C:

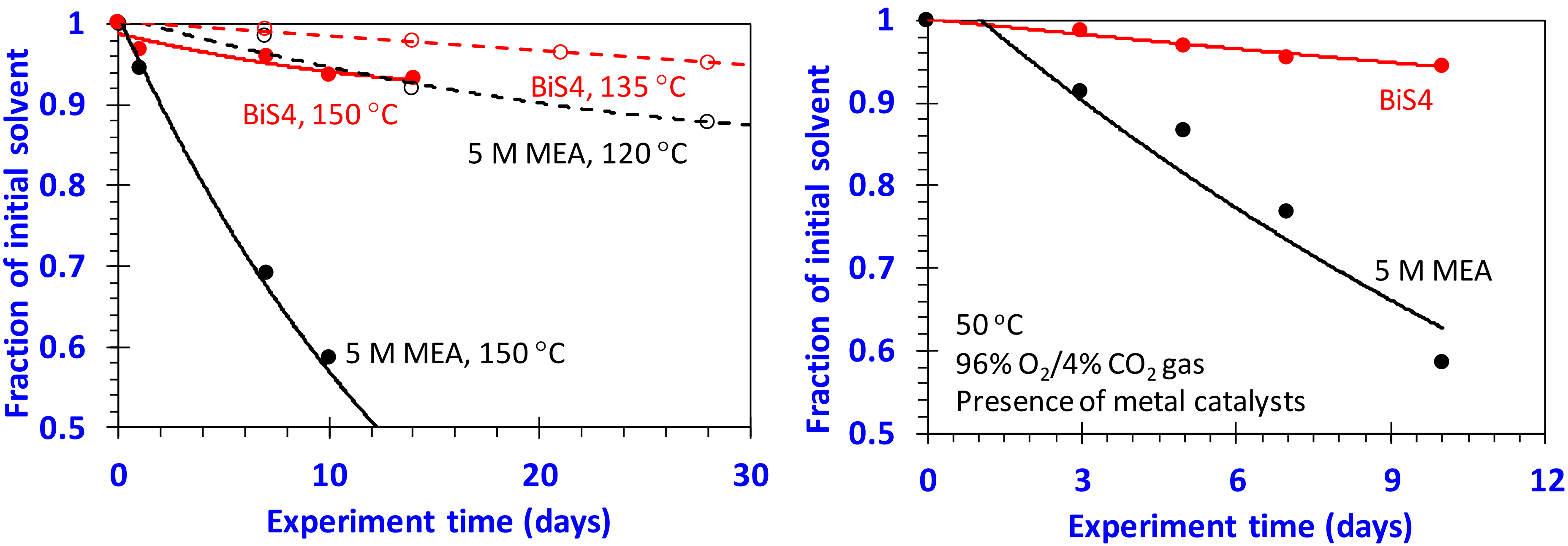
- Rates slightly faster than (at both lean and rich loadings) or comparable with (faster at lean loading and slower at rich loading) 5M MEA

Reduced Viscosity for CO_2-Saturated Rich Phase



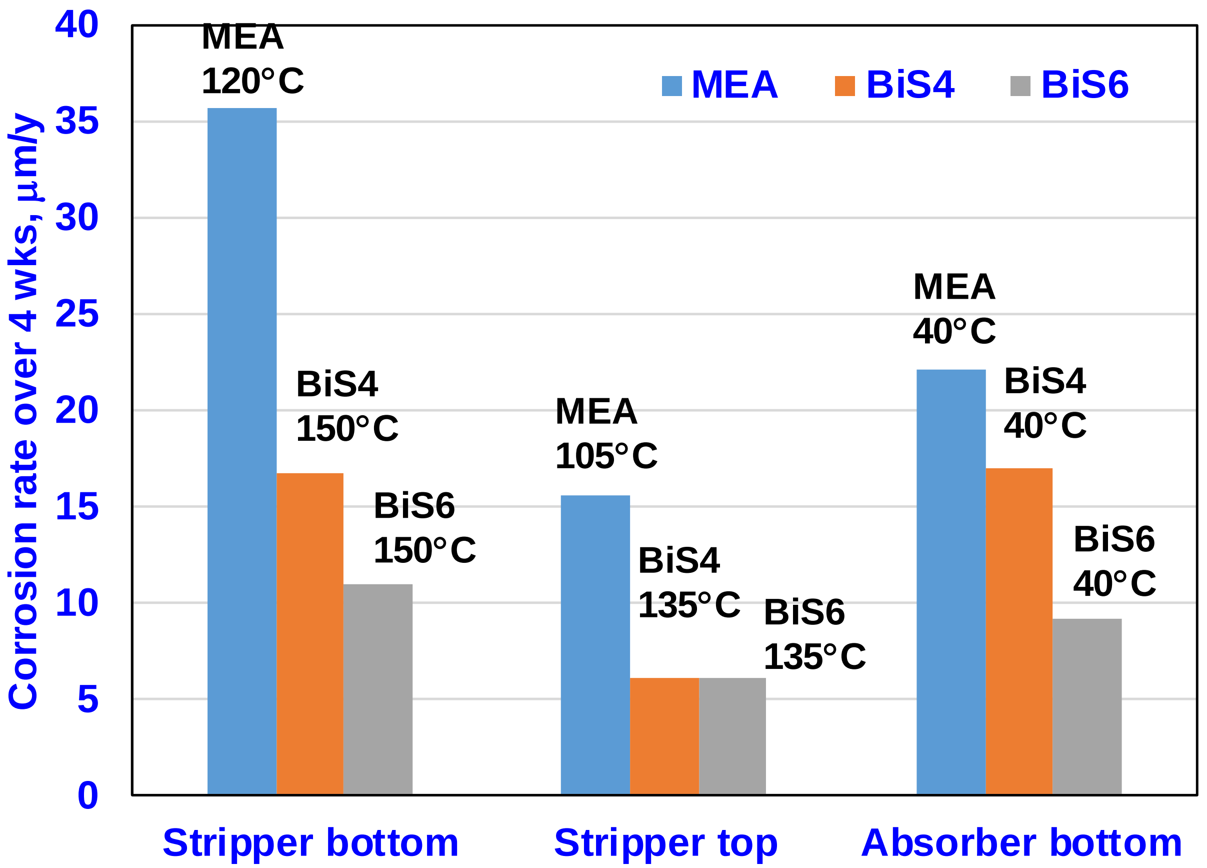
- Lean phase viscosity < 9 cP (data not displayed)
- Rich phase viscosity for the selected solvents <50 cP (most solvents <100 cp)

High Thermal and Oxidative Stabilities of Biphasic Solvents



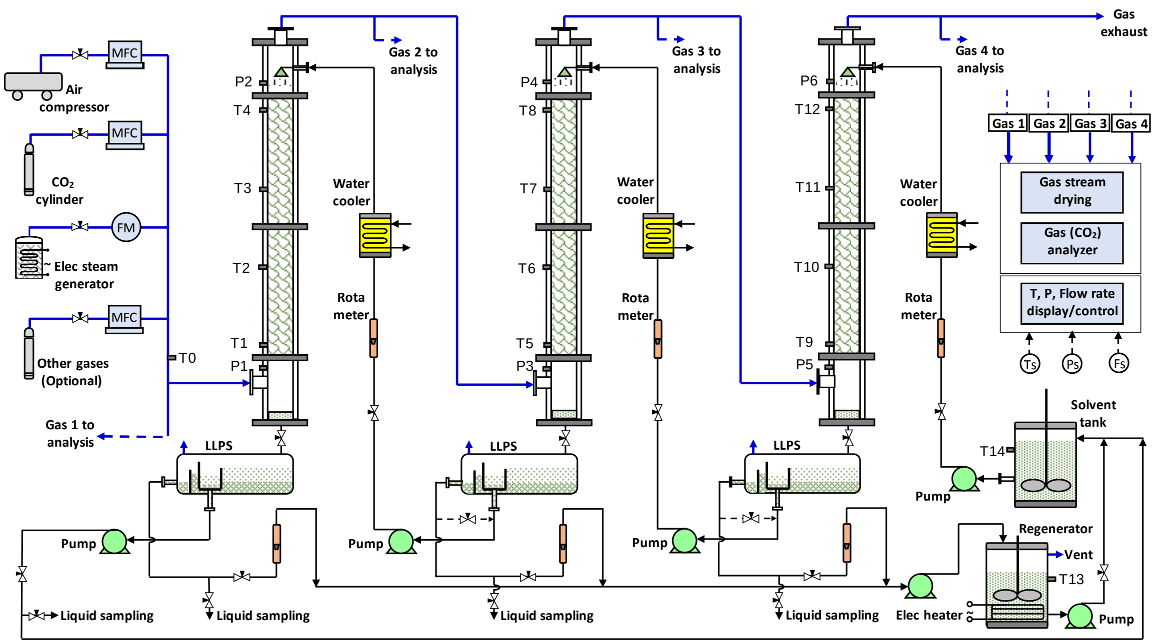
- Thermal stability
  - At 150°C for 14 days, ~5% BiS4 degradation vs. ~50% MEA loss
  - Stability of BiS4 at 150°C ≈ MEA at 120°C
- Oxidative stability
  - At 50°C for 10 days, ~5% BiS4 degradation vs. 40% MEA loss

Less Corrosion Effect with Biphasic Solvents



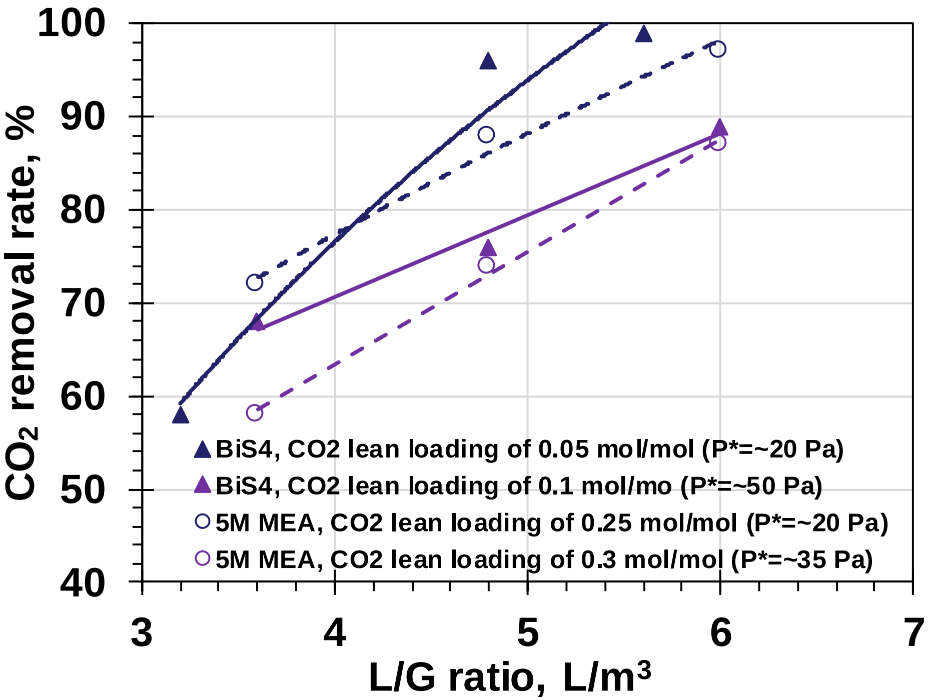
- Corrosion rate of carbon steel by BiS solvents 2-3 times < MEA
- Corrosion rate of stainless steel at 1.5-4 µm/y for either BiS or MEA (data not shown)

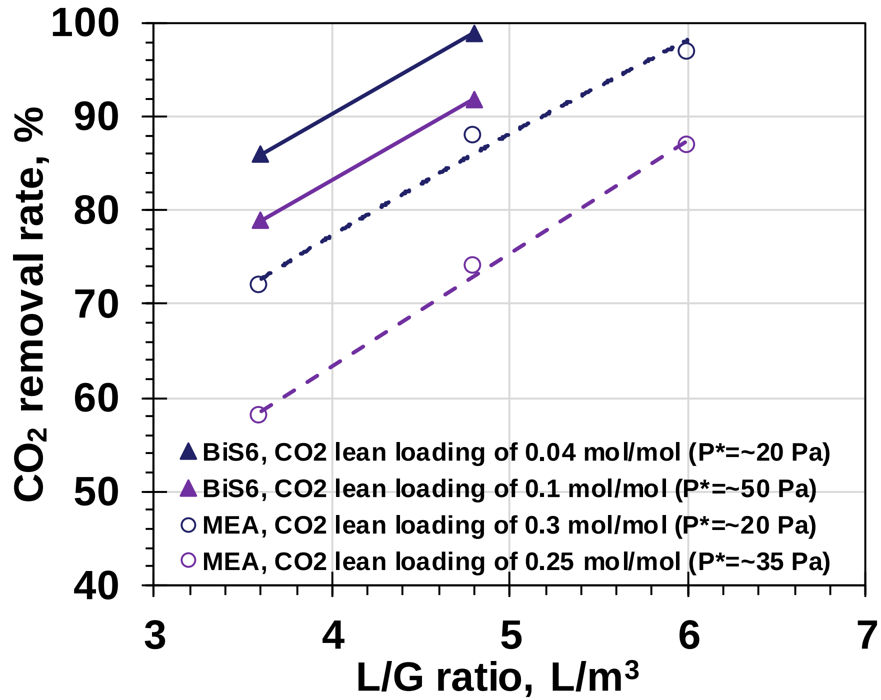
Laboratory 10 KWe Absorption Unit



- 3 stages of packed bed and phase separator (4-in ID, 7-ft packed-bed for each stage)
- 3 stages in one vertical column envisioned for practical use (arranged side by side in lab to accommodate ceiling limit)

Stable Operation with Multi-Stage LLPS & Absorption; Rates in Biphasic Solvents Faster Than MEA

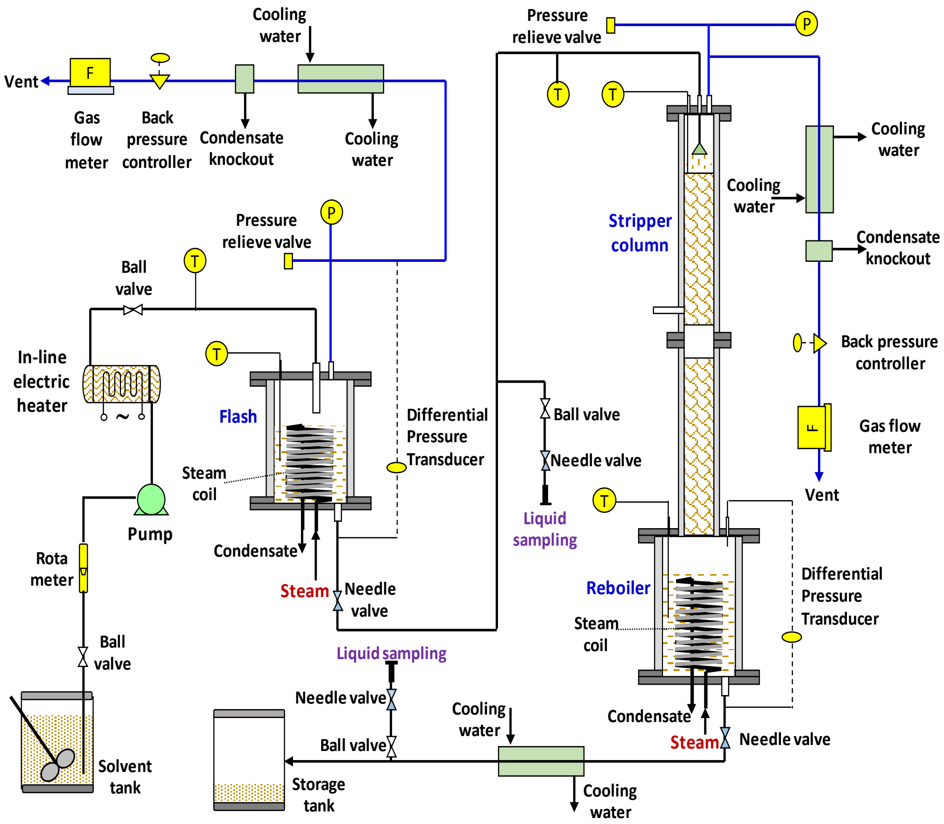


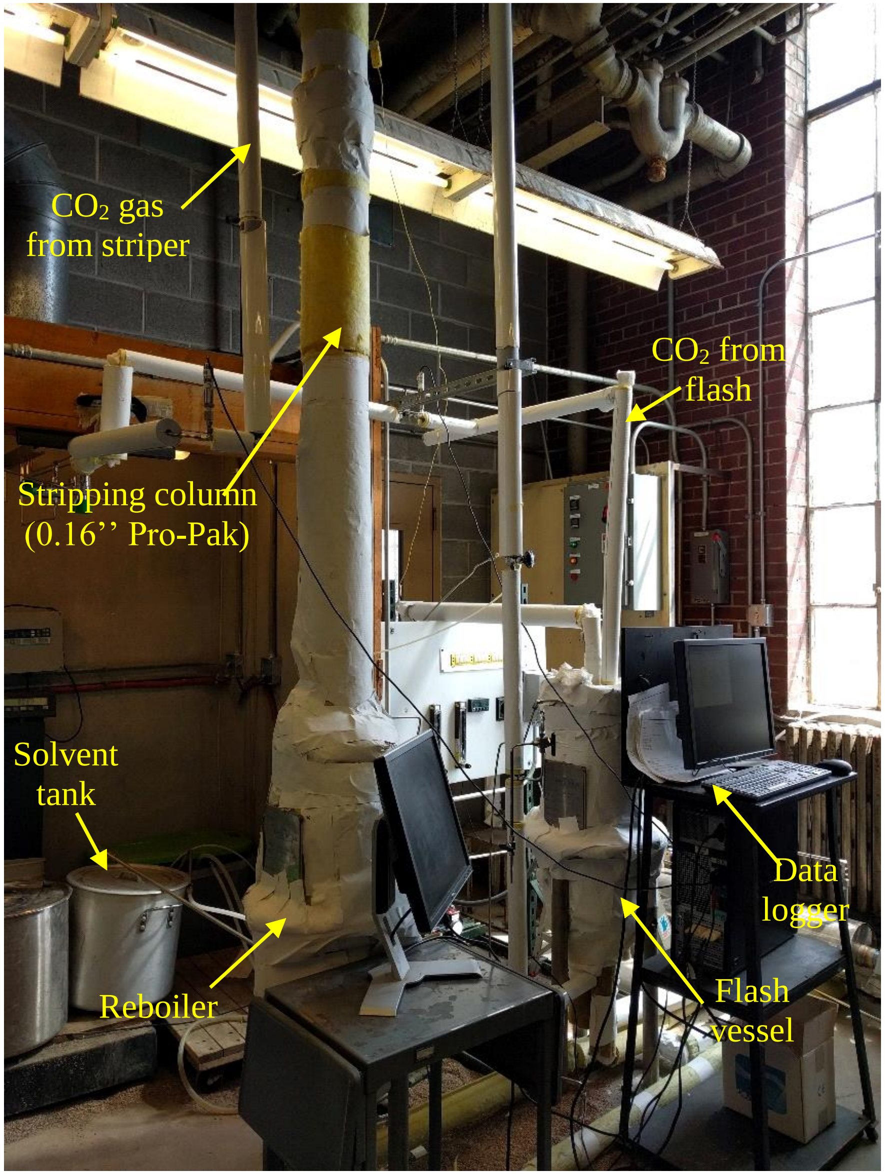


(3-stages of CO_2 absorption tests under 13 vol.% CO_2 in air at 35-40°C)

- CO_2 removal rate and loading capacity in the absorption step for the 2 selected solvents (BiS4 and BiS6) outperformed or comparable to 5M MEA under the same L/G and comparable CO_2 lean loading (equiv. to similar equilibrium P^*_{CO2} at 40°C)

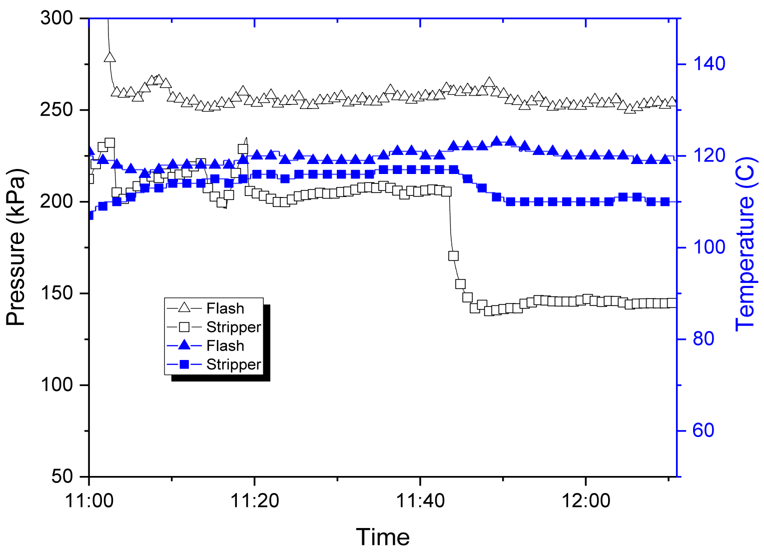
Laboratory 10 KWe Desorption Unit

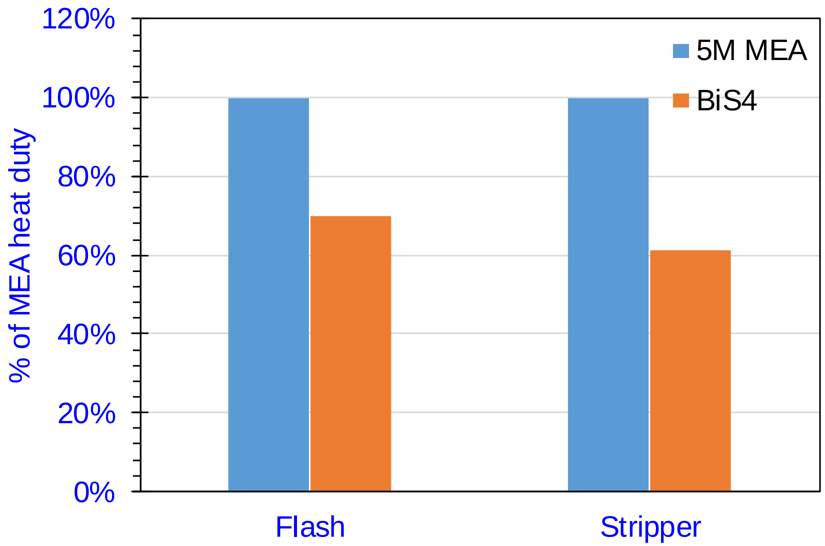


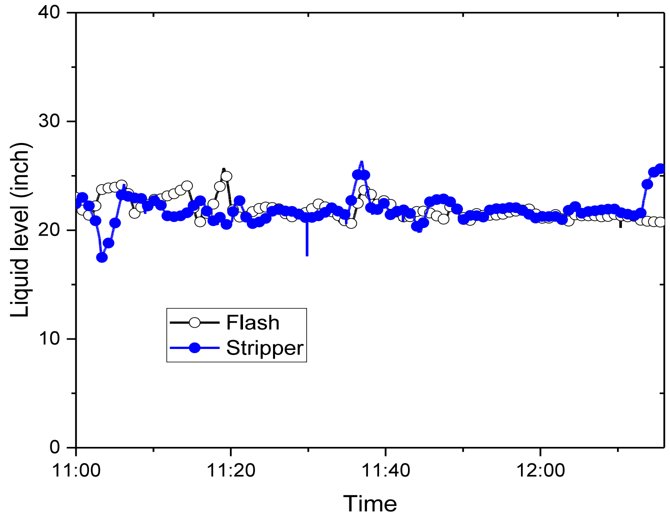


- Flash vessel: 5'' ID × 2' H; max. 3 kW_{th} reboiler
- Stripping column: 2'' ID × 9' H (2 beds) with 0.16'' ProPak; max. 6 kW_{th} reboiler

Stable Operation of Combined Flash + Stripper; Experiments Ongoing







- Stable operation of the integrated flash and stripper system
- Heat duty for BiS4 lower than MEA by 30-40% under representative conditions

Summary of Key Results from Preliminary Process Analysis

	BiCAP	DOE Case 12 Rev 2a	Difference vs. Case 12
CO_2 Capture & Compression Total Plant Costs 2007$	**$378 MM**	**$469 MM**	**-19%**
Total Parasitic Demands (MWe)	**176**	**252**	**-30%**
Capture Plant Steam Derate	103	139	-26%
Capture Plant Direct Electrical Derate	39	75	-48%
Power Plant Auxiliary Load	34	38	-10%
Other			
Solvent Make-Up Costs Due to Degradation	$2MM	$1MM	+100%

Preliminary Energy Performance Analysis for an Updated Process Configuration

	BiCAP*	DOE Case 12 (MEA)	DOE Case B12B (Cansolv)
Net Generating Capacity, MWe	**550**	**550**	**550**
Gross Generating Capacity, MWe	**700**	**802**	**728**
Amount of CO_2 captured, tonne/hr	**478**	**548**	**480**
Total Steam Derate, MWe	**71.1**	**139**	**86**
Reboiler/Flash Heat Duty, MWth	278	542	331
Thermal to Electric Energy, %	25.6	25.6	25.8
Direct Electrical Derate, MWe	**44.8**	**75.2**	**51.7**
Compression Duty, MWe	31.5	44.9	35.7
Other (Pumps, Fans, etc.), MWe	13.3	30.3	16.0
Total Derate for CO_2 Capture, MWe	**116**	**214**	**137**
Total parasitic use for entire plant, MWe	**150**	**252**	**178**

* Updated BiCAP case (Cold rich feed bypass the heat exchanger)

- Parasitic power use: 16.6% for BiCAP, 25.4% for MEA, 18.8% for Cansolv
- Total derate for BiCAP is 43%< MEA, 15%<Cansolv

Risks and Mitigation Strategies

Description of Risk	Risk Mitigation and Response Strategies
New stripping process configuration is unable to achieve the energy use target (reboiler heat duty <2,100 kJ/kg of CO_2 captured)	1) Stripping configuration will be modified / improved (e.g., by optimizing locations of solvent feeds, etc.) 2) Solvent formula will be revisited (e.g., tradeoff between energy-related and operation/cost-related solvent properties) 3) Operating conditions will be optimized (e.g., temperature, CO_2 rich/lean loadings, etc.)
Performance of multiple stages of the absorption and phase separation configuration is less favorable than expected for higher viscosity solvents, and the operation is complex	1) One stage of CO_2 absorption and phase separation configuration will be considered and its performance assessed; 2) Issues related to operational complexity will be analyzed, and the most complicated and expensive units and equipment will be identified
Solvent management issues arise, such as emission loss, corrosion, handling, and supply	1) Solvent volatile emissions will be assessed in lab to provide inputs for design of a water wash unit in absorber; 2) Our previous corrosion study will guide equipment material selections; 3) Reclamation of thermal and oxidative degradation products to mitigate their corrosion effects will be investigated; 4) UIUC Division of Research Safety, power plant, and solvent suppliers will be consulted on solvent safe use and handling; 5) Multiple vendors will be contacted to confirm solvent supply
Economics (CAPEX and OPEX) of technology is less favorable than expected	1) Issues related to high CAPEX and OPEX will be assessed; 2) The most complicated and expensive subunits & equipment will be identified and alternatives investigated; 3) Process configuration and solvent formulation will be re-assessed to identify potential solutions to reduce costs

Cont'd

Description of Risk	Risk Mitigation and Response Strategies
Flue gas and utilities are unavailable from the host power plant for 2-week testing in BP3	1) Obtain the commitment letter from Abbott power plant in BP1 (2 years before the testing); 2) Close and early coordination with Abbott power plant to schedule the testing time and ensure continuous plant operation for 2 weeks; 3) Supply of most utilities (electricity, steam, water, cooling, waste disposal, etc.) will be built in the bench skid and self-supported
Project cost (bench-scale equipment cost) has overruns	1) Project scope will be clearly defined with suppliers and change orders limited; 2) A fixed-price basis will be adopted to avoid suppliers that bid low and escalate costs over time; 3. Size of the bench unit will be reduced
Bench-scale equipment procurement bidding process is delayed	1) Close coordination with UIUC Purchasing Division early on to ensure that procurement bidding process starts timely and is completed efficiently; 2) Equipment design and specs will be made available to UIUC Purchasing Division as early as possible to prepare bidding documentation
Fabrication of bench-scale equipment is delayed	1) A reputable supplier will be chosen and firm commitments made during purchase order; 2) Close communications and oversight will be maintained, and issues will be resolved as they occur during the fabrication

Technical Background

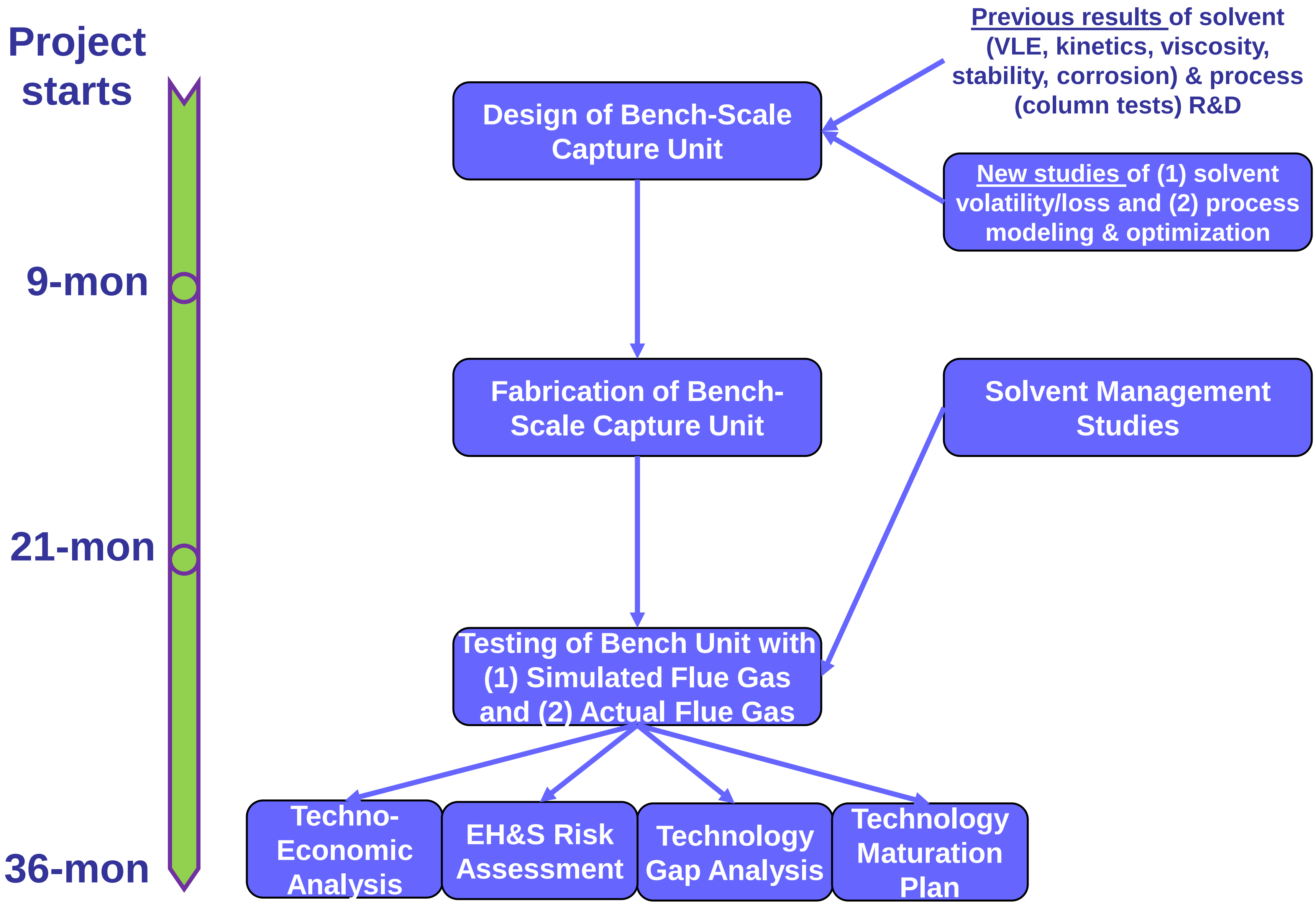
Project Task Flow and Organization

Scope of Work and Approaches

Project Timeline and Milestones

Plan for Future Scale-Up /Development

Decision Tree of Technical Work



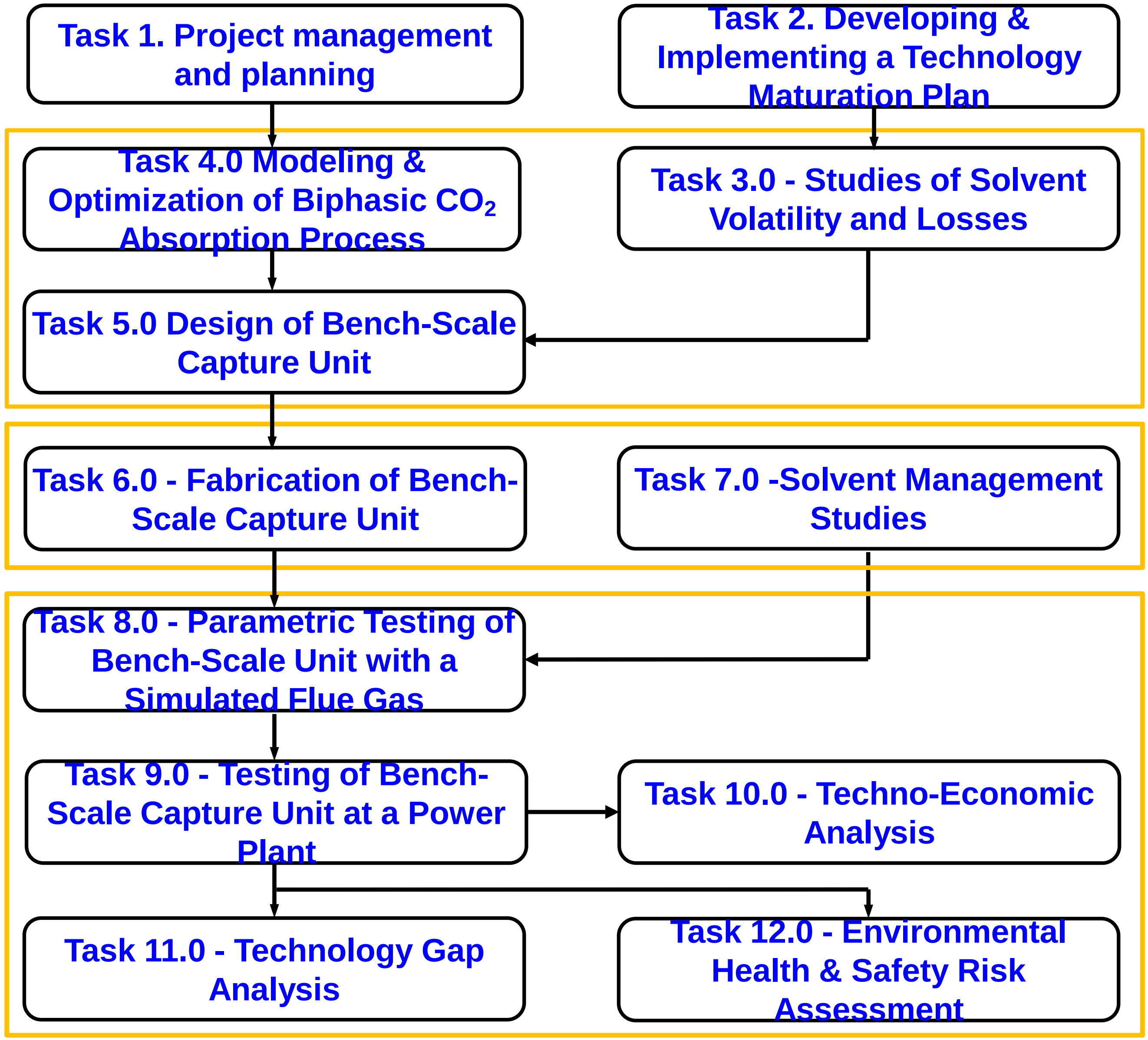
Project Task Logic Flow

BP1 (9 mon): Process modeling & bench unit design

BP2 (12 mon): Bench unit fab and solvent studies

BP3 (15 mon): Bench-scale testing;

TEA, tech gaps, and EH&S risk studies



Project Task Logic Flow

USDOE/NETL
Contracting Officer's Representative

UIUC
PI: Yongqi Lu; Co-PI: Kevin O'Brien

Trimeric Corporation
Subcontractor PI: Ray McKaskle

- **Task 2.0 - Developing & Implementing a Technology Maturation Plan**
- **Task 3.0 - Studies of Solvent Volatility and Losses**
- **Task 4.0 - Modeling & Optimization of Biphasic CO2 Absorption Process**
- **Task 6.0 - Fabrication of Bench-Scale Capture Unit**
- **Task 7.0 -Solvent Management Studies**
- **Task 8.0 - Parametric Testing of Bench-Scale Unit with a Simulated Flue Gas Stream**
- **Task 9.0 - Testing of Bench-Scale Capture Unit at a Power Plant**
- **Task 11.0 - Technology Gap Analysis**
- **Task 12.0 - Environmental Health & Safety Risk Assess**

- **Task 5.0 - Design of Bench Capture Unit**
- **Task 10.0 - Techno-Economic Analysis**

Provide Assistance in:

- **Task 6.0**

Provide equipment specs;
Provide oversight of equipment fab;
Attend reviews & factory acceptance testing

- **Task 8.0**

Installation and commissioning

- **Task 9.0**

Field test preparation/commissioning

Technical Background

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Task 2. Developing & Implementing a Technology Maturation Plan (TMP)

- Initial TMP within 90 days of award; updated at significant milestones/ project transition

- TMP contents
  - Current TRL and target applications
  - For proposed work:
    - Performance attributes and their requirements;
    - Performance attributes to be tested;
    - Work needed to meet requirements;
    - Anticipated TRL
  - Post-project plans attain next TRL

BP1: Task 3. Studies of Solvent Volatility & Losses

- Solvent volatility measurement
  - Organic vapors of individual components at absorption conditions measured by FTIR using an existing VLE cell

- Testing of solvent emission and mitigation
  - Solvent losses (vapor & aerosols) tested in an existing lab column with a water wash section added downstream
  - 2-3 trays and/or packings to be evaluated (e.g., water flow, temperature, inlet SO_3 concentration, etc.)
  - Vapor analyzed by FTIR and aerosols collected by membrane filters and analyzed by TOC, etc.

Task 4. Modeling and Optimization of Biphasic CO_2 Absorption Process

- Process modeling to identify optimal configuration
  - Use a rigorous Aspen Plus® model developed from our previous work
  - Based on solvent data from our previous work

- Bench-scale process simulations to provide mass & energy balance information for 40 kWe unit design

Task 5. Design of Bench-Scale Capture Unit

- Design of 40 kWe bench-scale capture unit (skid-mounted)
  - Design basis from Task 4
  - An equipment list (including gas polishing and utilities supply) developed and sized/selected
  - (Utilities not from power plant host site but self-supported)
- Design review and approval
- Conduct a preliminary hazards and operability (HAZOP) analysis for the bench-scale unit design

BP2: Task 6. Fab of 40 kWe Bench-Scale Capture Unit

- Bidding solicitation & selection of a manufacturing vendor
  - Bid specs prepared
  - RFP/solicitation
  - Assessment of bids and vendor selection

- Fabrication of skid-mounted capture unit
  - Oversight for equipment fabrication to ensure that the schedule and design requirements are met
  - Safety reviews and factory-acceptance testing at the vendor’s facility

Task 7. Solvent Management Studies

- Solvent degradation and reclamation studies
  - Ion exchange and adsorption tested to reclaim solvents
  - Commercial and ISGS materials to be evaluated

- Develop in-situ measurement of CO_2 loading
  - Develop correlations between CO_2 loading and an easy-to-measure property (e.g., density)

BP3: Task 8. Parametric Testing of Bench-Scale Unit with a Simulated Flue Gas Stream

- Installation and commissioning
  - Installation in a lab
  - Operating procedures, test plans and safety plans developed
  - Troubleshooting and commissioning tests

- Parametric Testing
  - Parametric Testing for 2 selected solvents
  - Scheduled for a total of 6 months

Task 9. Testing of Bench-Scale Capture Unit at a Power Plant

- Field test preparation
  - Field-test plan prepared
  - Safety plans and training prepared
  - Skid installed and commissioned

- Bench-scale testing with Abbott flue gas
  - One biphasic solvent selected from Task 8
  - Capture performance tested for 2 weeks
  - Liquid samples collected for degradation analysis
  - Corrosion effects on coupons evaluated
  - Monitoring of amine emissions

Task 10. Techno-Economic Analysis

- Process analysis and updating of mass & energy balances
  - Identify potential process improvement or optimization opportunities
  - Mass & energy balance info updated/scaled to 550 MWe (net)

- Techno-Economic Analysis
  - Major equipment selected and sized
  - CAPEX and OPEX updated (from the lab-scale project)
  - Economic metrics (e.g., COE, capture cost) estimated
  - Sensitivity analysis with key technical and cost variables

Task 11. Technology Gap Analysis

- Review of the process and summary of the potential advantages (e.g., performance, cost, emissions, market, safety metrics)
- Summary of current R&D level on key components or subunits; Info & testing required for scale-up/ commercialization
- Summary table of R&D gaps as focus of future R&D efforts or being investigated thru other programs
- Potential vendors and specs identified for commercially-available equipment items

Task 12. Environmental, Health & Safety Risk Assessment

- Substances of air, water and solid wastes identified and their magnitude estimated
- Literature search of toxicological effects, human health effects, and eco-toxicity of the substances
- Properties (volatility, flammability, explosivity, other chemical reactivity, & corrosivity) collected from literature or if necessary, measurements
- Compliance and regulatory implications of the technology with reference to US EH&S laws and standards
- Engineering analysis for eliminating or minimizing use of hazardous materials and possible controls/mitigation options
- Precautions for safe handling and conditions for safe storage; Waste treatment and offsite disposal options examined

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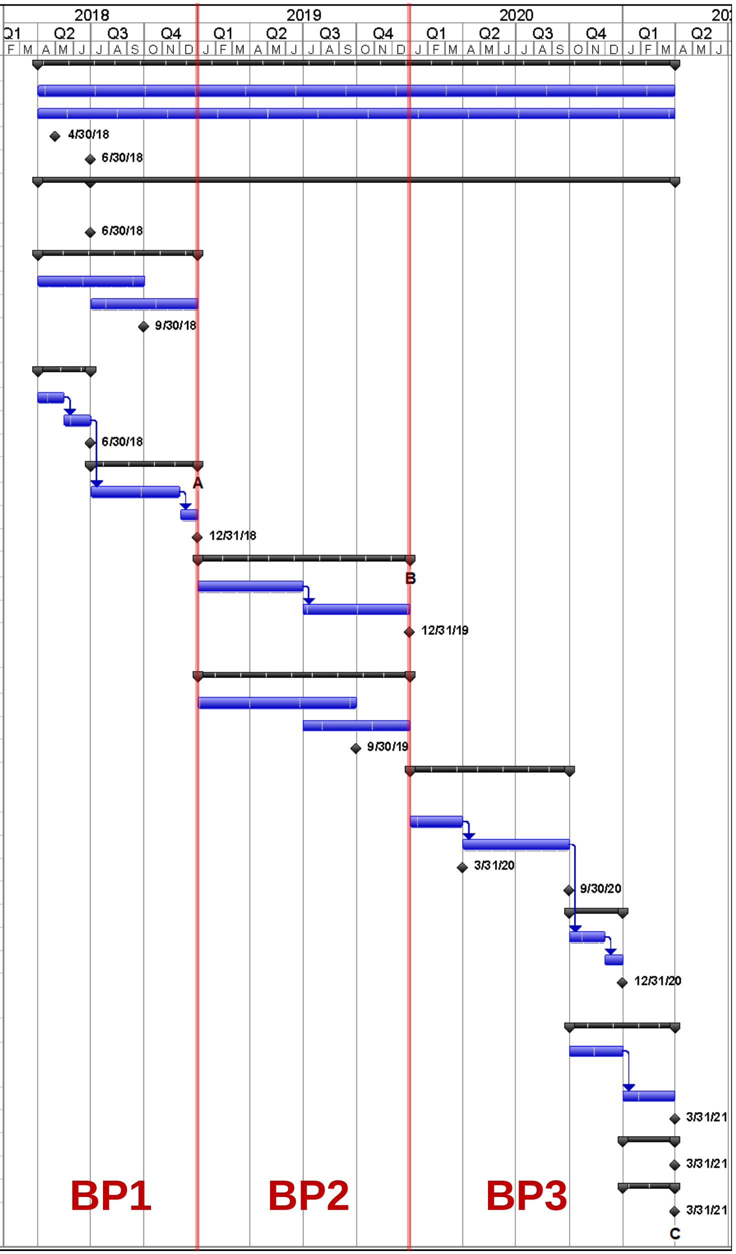
Schedule and Milestones (36-mon, 4/6/18-4/5/21)

ID	Task Name	Start	Finish	Resource Names
1	**Task 1.0 - Project Management and Planning**	**4/1/18**	**3/31/21**	**UIUC**
2	1.1 - Project Monitoring and Control	4/1/18	3/31/21	UIUC
3	1.2 - Briefings and Reports	4/1/18	3/31/21	UIUC,Trimeric
4	a - Updated Project Management and Planning	4/30/18	4/30/18	
5	b - Project kickoff meeting	6/30/18	6/30/18	
6	**Task 2.0 - Developing & Implementing a Technology Maturation Plan**	**4/1/18**	**3/31/21**	**UIUC**
7	c - Technology Maturation Plan prepared	6/30/18	6/30/18	
8	**Task 3.0 - Studies of Solvent Volatility and Losses**	**4/1/18**	**12/31/18**	**UIUC**
9	3.1 - Solvent Volatility Measurement	4/1/18	9/30/18	UIUC
10	3.2 - Testing of Solvent Losses in a Laboratory Absorption Column	7/1/18	12/31/18	UIUC
11	d - Volatility measurement and preliminary results of water wash performance obtained	9/30/18	9/30/18	
12	**Task 4.0 - Modeling & Optimization of Biphasic CO2 Absorption Process**	**4/1/18**	**6/30/18**	**UIUC**
13	4.1 - Process Modeling and Optimization	4/1/18	5/15/18	UIUC
14	4.2 - Bench-Scale Unit Process Simulations	5/16/18	6/30/18	UIUC
15	e - Optimal process configuration identified	6/30/18	6/30/18	
16	**Task 5.0 - Design of Bench-Scale Capture Unit**	**7/1/18**	**12/31/18**	**Trimeric**
17	5.1 - Design of Bench-Scale Capture Unit	7/1/18	11/30/18	Trimeric
18	5.2 - Design Review and Approval	12/3/18	12/31/18	Trimeric
19	f - Bench-scale equipment design completed	12/31/18	12/31/18	
20	**Task 6.0 - Fabrication of Bench-Scale Capture Unit**	**1/1/19**	**12/31/19**	**UIUC,Trimeric**
21	6.1 - Bidding Solicitation and Selection of a Manufacturing Vendor	1/1/19	6/30/19	Trimeric,UIUC
22	6.2 - Fabrication of Bench-Scale Capture Unit	7/1/19	12/31/19	UIUC,Trimeric
23	g - Bench-scale unit fabricated and factory acceptable test completed	12/31/19	12/31/19	
24	**Task 7.0 -Solvent Management Studies**	**1/1/19**	**12/31/19**	**UIUC**
25	7.1 - Solvent degradation and reclamation study	1/1/19	9/30/19	UIUC
26	7.2 - CO2 loading correlation and in-situ measurement	7/1/19	12/31/19	UIUC
27	h - Solvent reclamation option identified	9/30/19	9/30/19	
28	**Task 8.0 - Parametric Testing of Bench-Scale Unit with a Simulated Flue Gas Stream**	**1/1/20**	**9/30/20**	**UIUC,Trimeric**
29	8.1 - Installation and Commissioning	1/1/20	3/31/20	Trimeric,UIUC
30	8.2 - Parametric Testing of Bench-Scale Unit	4/1/20	9/30/20	UIUC
31	i - Bench-scale unit installed on skid	3/31/20	3/31/20	
32	j - Parametric testing of bench-scale unit completed	9/30/20	9/30/20	
33	**Task 9.0 - Testing of Bench-Scale Capture Unit at a Power Plant**	**10/1/20**	**12/31/20**	**UIUC,Trimeric**
34	9.1 - Field Test Preparation	10/1/20	11/30/20	UIUC,Trimeric
35	9.2 - Bench-scale Testing with Actual Flue Gas	12/1/20	12/31/20	UIUC
36	k- Field testing with a slipstream of coal combustion flue gas completed	12/31/20	12/31/20	
37	**Task 10.0 - Techno-Economic Analysis**	**10/1/20**	**3/31/21**	**Trimeric**
38	10.1 - Process Analysis and Updating Mass & Energy Balance Calculations	10/1/20	12/31/20	Trimeric
39	10.2 - Techno-Economic Analysis	1/1/21	3/31/21	Trimeric
40	l - Techno-Economic Analysis topical report completed	3/31/21	3/31/21	
41	**Task 11.0 - Technology Gap Analysis**	**1/1/21**	**3/31/21**	**UIUC**
42	m - Technology Gap Analysis topical report completed	3/31/21	3/31/21	
43	**Task 12.0 - Environmental Health and Safety Risk Assessment**	**1/1/21**	**3/31/21**	**UIUC**
44	n - Environmental Health & Safety Risk Assessment topical report completed	3/31/21	3/31/21	



Project Milestone Log (BP1)

ID	Task	Milestone Description	Planned Completion	Verification Method
a	1	Updated Project Management Plan (PMP) submitted	4/30/18	PMP file
b	1	Project kickoff meeting convened	6/30/18	Presentation file
c	2	Technology Maturation Plan (TMP) submitted	6/30/18	TMP file
d	3	Volatility measurements and preliminary results of water wash performance obtained	9/30/18	Results reported in QR report
e	4	Optimal process configuration identified	9/30/18	Results reported in QR report
f	5	Bench-scale equipment design completed	12/31/18	Results reported in QR report
g	5	Host Site Agreement obtained	12/31/18	Host Site Agreement submitted to DOE

Cont'd (BP2)

ID	Task	Milestone Description	Planned Completion	Verification Method
h	6	h. Bench-scale unit fabricated and factory-acceptable test completed	12/31/19	Description and photographs provided in QR report
i	7	i. Solvent reclamation options identified	9/30/19	Results reported in QR report

Cont'd (BP3)

ID	Task	Milestone Description	Planned Completion	Verification Method
j	8.1	Bench-scale unit installed	3/31/20	Description & photographs provided in QR report
k	8.2	Parametric testing with simulated flue gas in lab completed	9/30/20	Results reported in QR report
l	9	Field test plan prepared	11/30/20	Field test plan reported in QR report
m	9	Field testing with a slipstream of actual flue gas completed	12/31/20	Results reported in QR report
n	10	TEA topical report completed	3/31/21	Results reported in QR report and a topical report
o	10	State-Point Data Table updated	3/31/21	Updated State-Point Data Table in QR report
p	11	Technology Gap Analysis topical report completed	3/31/21	Results reported in QR report and a topical report
q	12	EH&S Risk Assessment topical report completed	3/31/21	Results reported in QR report and a topical report

Success Criteria

Decision Point	Basis for Decision/Success Criteria
Completion of Budget Period 1	Development and submission of a TMP
	Completion of solvent volatility measurements and a preliminary assessment of water wash options and performance
	Host site agreement finalized
	Completion of 40 kWe bench unit design, with design calculations meeting performance targets (e.g., heat duty <2,100 GJ/tonne of CO_2 and stripping P >4 bar)
Completion of Budget Period 2	Completion of solvent reclamation tests and identification of options suitable for reclamation of biphasic solvents
	Fabrication of 40 kWe bench-scale skid and factory-acceptance test passed on schedule
Completion of Budget Period 3	**Completion of bench-scale testing, including parametric testing with a simulated flue gas and slipstream testing of actual flue gas at Abbott**; Results showing total energy use of $\leq$0.22 kWh//kg (including estimated compression work) that indicate significant progress toward achieving the DOE’s Transformational Capture goals
	Submission of (1) an updated State-Point Data Table; (2) a TEA topical report; (3) a Technology Gap Analysis topical report; and (4) an EH&S Risk Assessment topical report

Project Deliverables

Task	Deliverable Title	Anticipated Delivery Date
1.0	Project Management Plan	Update due 30 days after award; Revisions submitted as requested
2.0	Technology Maturation Plan	Due 90 days after award; Revisions submitted as requested
5.0	Host Site Agreement	Delivery prior to BP2
9.0	Test Plan	Delivery prior to initiation of Task 9.2
10.0	State Point Data Table	Delivery 1 mon after completion of Task 10
10.0	Techno-Economic Analysis	Delivery 1 mon after completion of Task 10
11.0	Technology Gap Analysis	Delivery 1 mon after completion of Task 11
12.0	EH&S Risk Assessment	Delivery 1 mon after completion of Task 12
	Final Technical Report	Delivery 3 mon within completion of the project

Technical Background

Project Task Flow and Organization

Scope of Work and Approaches

Project Timeline and Milestones

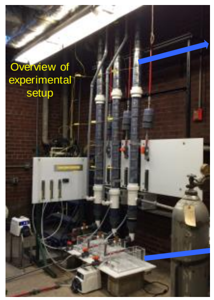
Plan for Future Scale-Up /Development

Progression of Technology Development

Currently

Solvent study, Laboratory

Proof-of-Concept
Funding: *UI (Part of Dissertation Research, 2013-2015)*



10 kWe Test, Laboratory

Separate Absorber / Stripper
Funding: *DOE / UI (2015-2018)*

40 kWe Test, Laboratory & Power Plant Slipstream

Bench Scale Close-Loop Unit
Funding: *DOE / UI (2018-2021)*

0.2-1 MWe, Power Plant /Test Center

Small Pilot
Funding: *DOE / UI / Corporate partners/ State*

10 MWe, Power Plant

Large Pilot
Funding: *DOE / Corporate Partners /State / UI*

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- DOE/NETL Contract Specialist: Bethan Young

Thank you!

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