Engineering-Scale Test of a Water-Lean Solvent for Post-Combustion Capture

DE-FE0031945

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2024 FECM/NETL Carbon Management Research Project Review Meeting
August 7, 2024

Acknowledgment

This material is based upon work supported by the Department of Energy under Award Number DE-FE0031945.

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Project Overview

DOE PM Dustin Brown

Project period October 2020 to September 2025

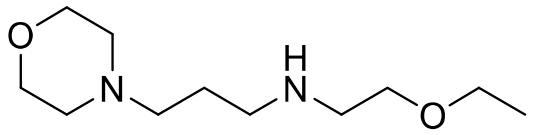
Funding

Federal	$5,088,677
Cost share	$1,272,169
Total	$6,360,846

Organizations

Electric Power Research Institute
Pacific Northwest National Lab.
RTI International
Paul M. Mathias Consulting, LLC
Gradient
Worley
Southern Company Services (NCCC)

Objective – Perform extended test campaigns on coal and natural gas flue gases with the EEMPA solvent operating at the ~0.5 MWe-equivalent scale for both coal and gas to verify its favorable performance characteristics while evaluating the environmental, health and safety (EH&S) risks of the technology and quantifying its potential to lower the cost of CO_2 capture.



N-(2-ethoxyethyl)-3-morpholinopropan-1-amine

or

EEMPA

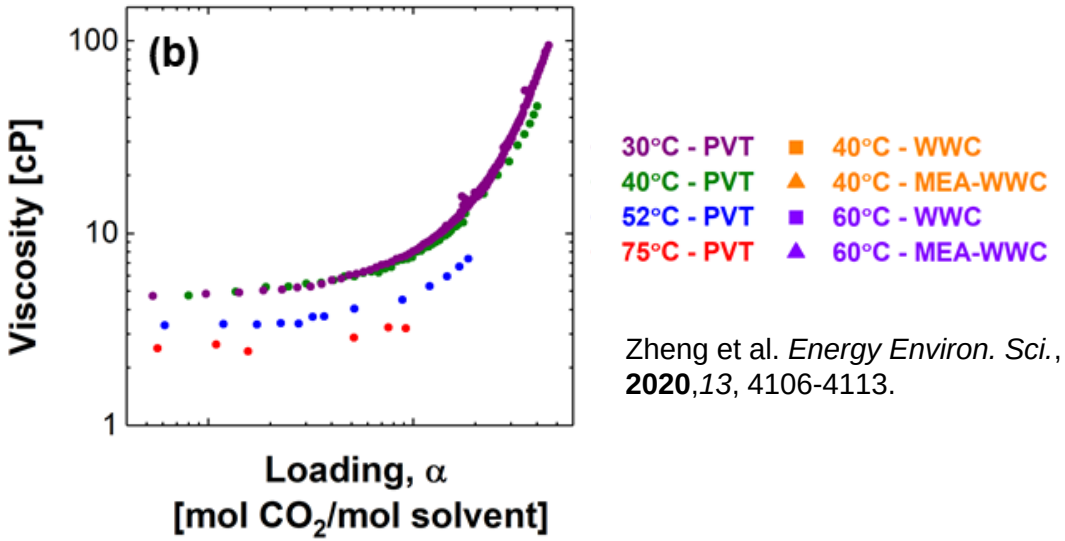
Overview of EEMPA's characteristics

Strengths

- Single-component, miscible in water
- Low viscosity gain upon reaction with CO_2
- Low surface tension
- Compatible with potentially cheaper materials of construction (e.g., plastics)
- Low corrosivity
- Good thermal and chemical stability
- Potential for advanced heat integration and regeneration steps that could save costs (e.g., flash regeneration)

Challenges

- Solvent is presently costly to produce, and large-scale production yet to be demonstrated
- Imposes need for careful control of the process water balance



Zheng et al. *Energy Environ. Sci.*, **2020**,*13*, 4106-4113.

EEMPA has several characteristics that make it a promising post-combustion capture solvent

Project Scope

Budget period 1 Oct 2020–July 2023	Develop new synthesis routes that could be scaled to manufacturing at lower cost Develop models and plan modifications to Pilot Solvent Test Unit Initial techno-economic analysis Initial environmental health & safety risk assessment
Budget period 2 August 2023–May 2024	Execute host site agreement Procure equipment and make modifications to the PSTU Manufacture the solvent Develop test plan and prepare for test
Budget period 3 June 2024–September 2025	Test campaigns on coal and natural gas representative flue gases Updated techno-economic analysis Updated environmental health & safety risk assessment

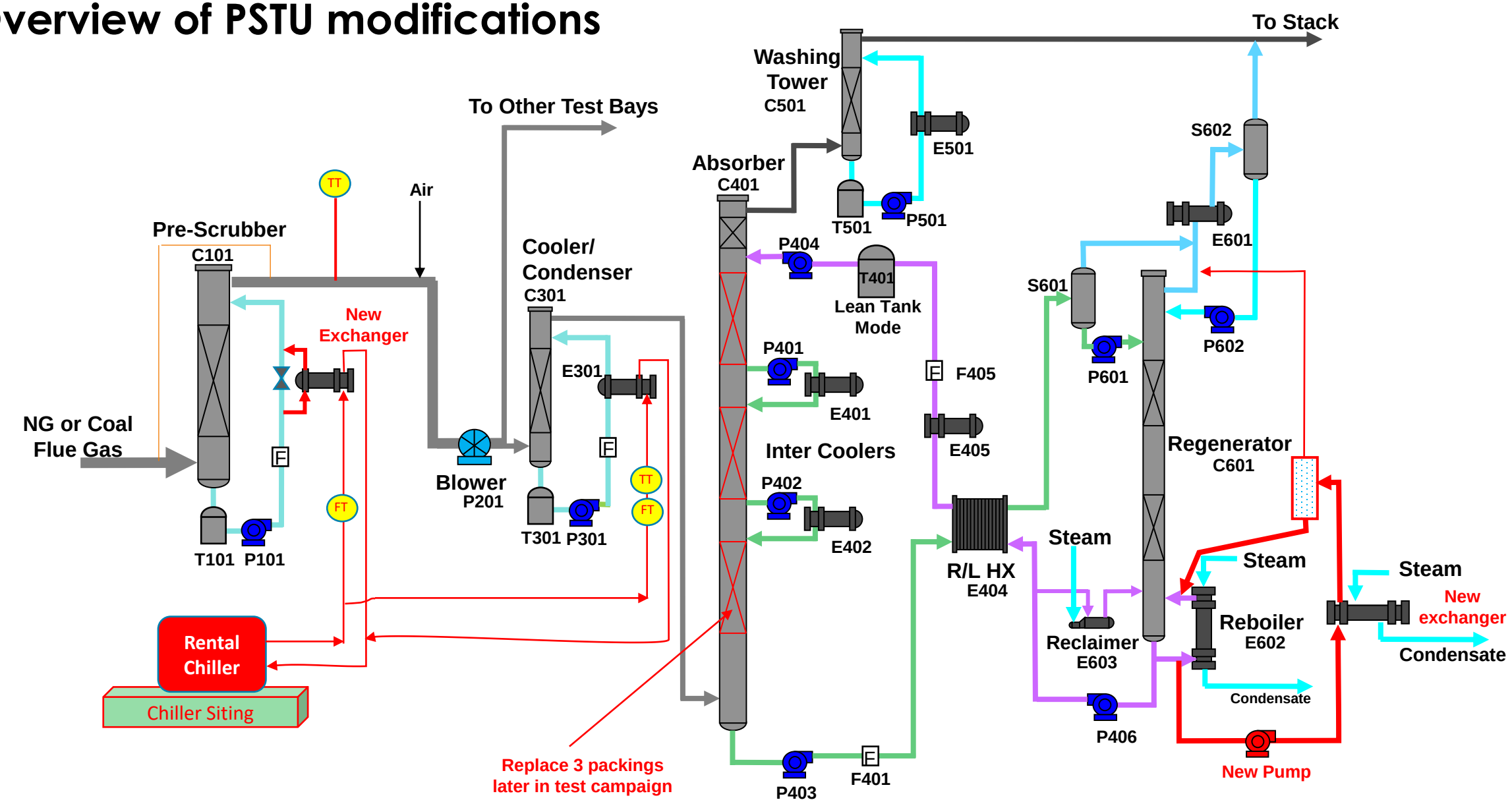
Progress preparations for testing

- Manufactured approx. 2,000 gallons of EEMPA and delivered to the National Carbon Capture Center (NCCC)
- Developed a Safety Data Sheet for EEMPA
- Developed an Aspen Plus model describing EEMPA in the Pilot Solvent Test Unit (PSTU)
- Modified the PSTU to accommodate EEMPA's operating characteristics
- Developed a cleaning procedure using dilute caustic to strip adsorbed amines from PSTU surfaces
- Installed Karl Fischer titrator and (soon) Raman spectrometer for tracking solvent composition during testing
- Developed a test plan covering coal- and natural gas-derived gases

Image courtesy of Southern Company Services

Pilot Solvent Test Unit (PSTU) at the National Carbon Capture Center

Overview of PSTU modifications



Courtesy of Southern Company Services

Test plan overview

Main goals

Get at least two months each of data on coal and natural gas flue gas

Achieve at least 90% capture, but will attempt higher capture rates if feasible

	Segment	Objective and remarks
Coal	1: Gas cooler rating	Determine achievable gas dew points
	2: Initial system start up	Achieve steady state operation
	3: Water balance test	Determine rate of water content changes
	4: L/G sweep	Initial scan of process parameter space
	5: Seq. design of experiments (SDOE)	Directed scan of process parameters to identify optimal conditions for steady operation (with CCSI^2)
	6: Steady state operation	Long term steady operation Emissions monitoring with PTR-TOF mass spec.
Natural gas	7: Gas cooler check	Determine achievable gas dew points
	8: L/G sweep	Initial scan of process parameter space
	9: SDOE	Directed scan of process parameters to identify optimal conditions for steady operation (with CCSI^2)
	10: Steady state operation	Long term steady operation
	11: Plastic packing	Repeat of steady testing on plastic packing

Solvent test set to begin soon

Upcoming Work

Completion of test campaigns

Anticipating completion of testing in early 2025

Techno-economic analysis

TEAs for both coal and natural gas power plant cases will be updated

Environmental, health, and safety risk assessment

Incorporate information on degradation products quantified during testing

Acknowledgments

Project team

EPRI
Kianna Marquez
Annette Rohr
Abhoyjit Bhown

Pacific Northwest National Laboratory
David Heldebrant
Charlie Freeman
Yuan Jiang
Dushyant Bargaa
Deepika Malhotra
Phillip Koech
Richard Zheng

Paul M. Mathias Consulting, LLC
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RTI International
Jak Tanthana
Marty Lail
Vijay Gupta
Paul Mobley
Moumita Bhattacharya
Cody Lucas
Colin Tart
Daniel Mogollon
Jacob Nelson

Support and collaboration

DOE/NETL
Dustin Brown
Dan Hancu
Ron Munson

NCCC
Tony Wu
Bob Lambrecht
Laura Uhrig

CCSI2
Joshua Morgan
Abby Nachtsheim
Jay Xu
Mike Matuszewski
Ben Omell
Yucheng Fu
Sham Bhat

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