Application of a Heat Integrated Post-Combustion Carbon Dioxide Capture System with Hitachi Advanced Solvent into Existing Coal-Fired Power Plant (FE0007395)

An Advanced Catalytic Solvent for Lower Cost Post-Combustion CO_2 Capture in a Coal-Fired Power Plant (FE0012926)

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http://www.caer.uky.edu/powergen/home.shtml

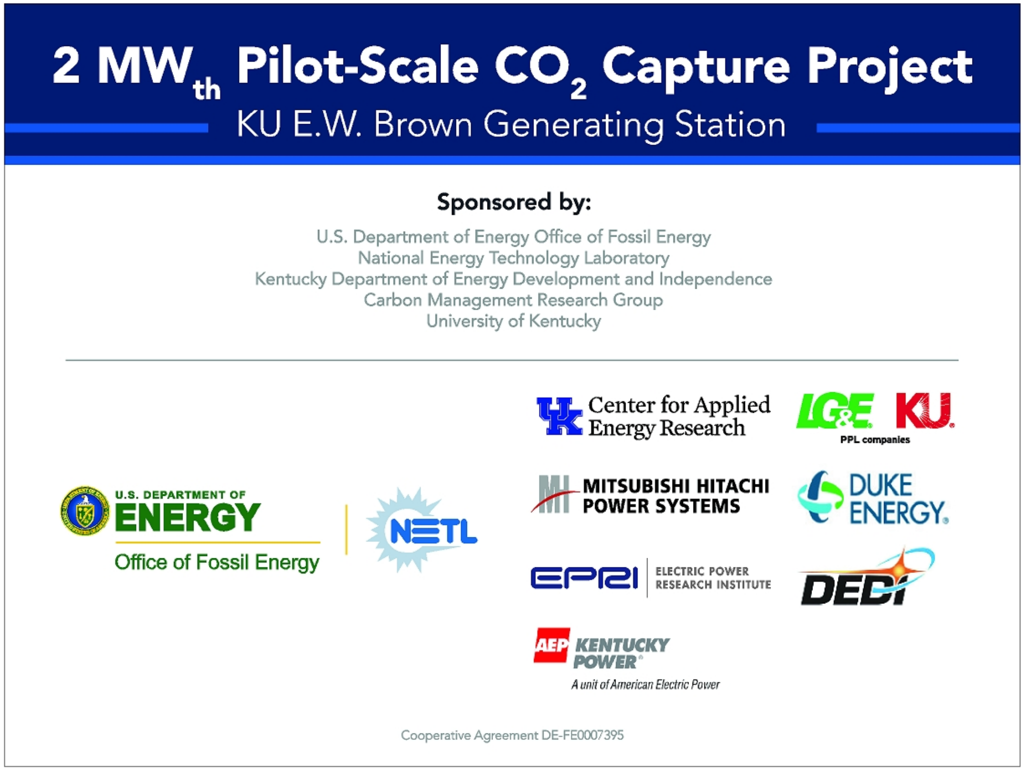
NETL CO_2 Capture Technology Meeting, Pittsburgh, PA, August 21-25, 2017

Project Summary

Motivation

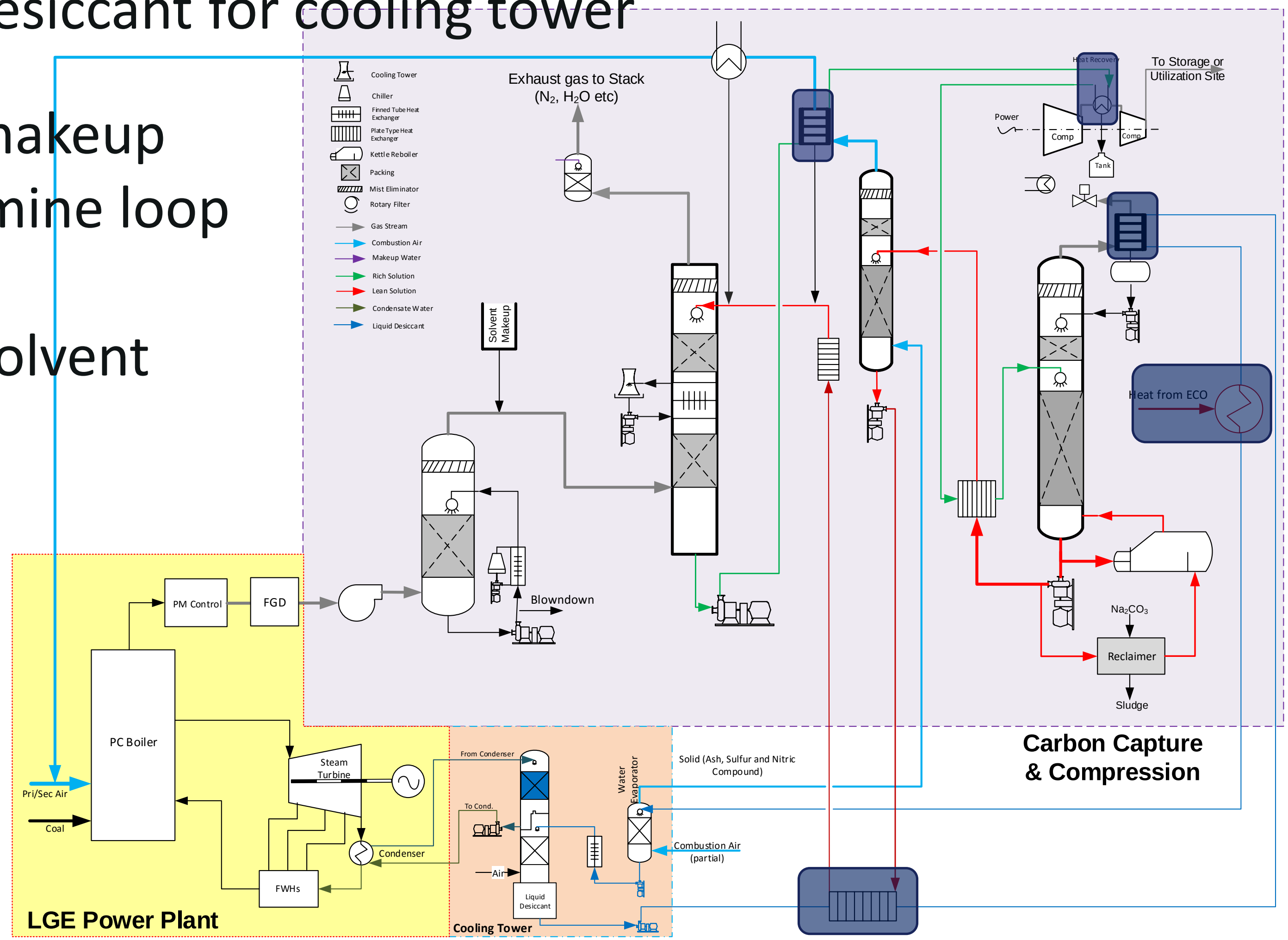
- Heat integration to recover rejected energy
- Thermal compression via enriched carbon loading to the stripper
- Reduced capital cost

Team Members



UKy-CAER Advanced Technology

- Utilization of low grade heat via internal heat pump
  - Secondary stripper
  - Liquid desiccant for cooling tower
- Near-zero makeup water for amine loop
- Advanced Solvent



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Small Pilot Project Overview

- 0.7 MWe (2 MWth) advanced post-combustion CO_2 capture pilot
- Catch and release program
- Designed as a modular configuration
- Testing at Kentucky Utilities E.W. Brown Generating Station in Harrodsburg, KY, approximately 30 miles from UKy-CAER
- Includes several UKy-CAER developed technologies
- Two solvent testing campaigns (MEA baseline and advanced H3-1)

Small Pilot Project Performance Dates

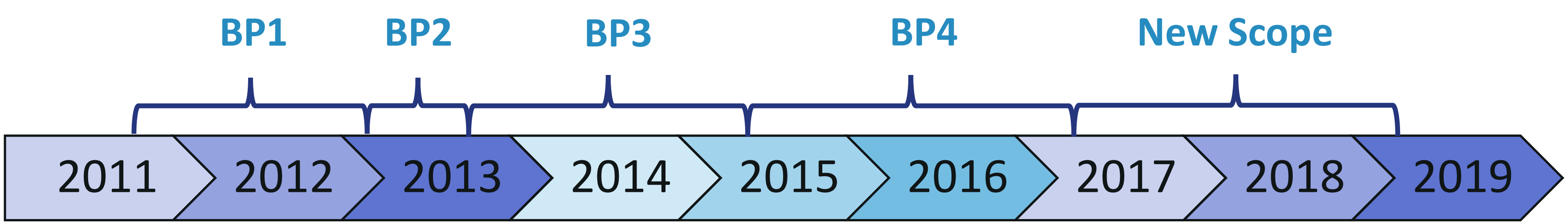
BP1: October 1, 2011 to January 31, 2013 (16 months)

BP2: February 1, 2013 to August 31, 2013 (7 months)

BP3: September 1, 2013 to March 31, 2015 (19 months)

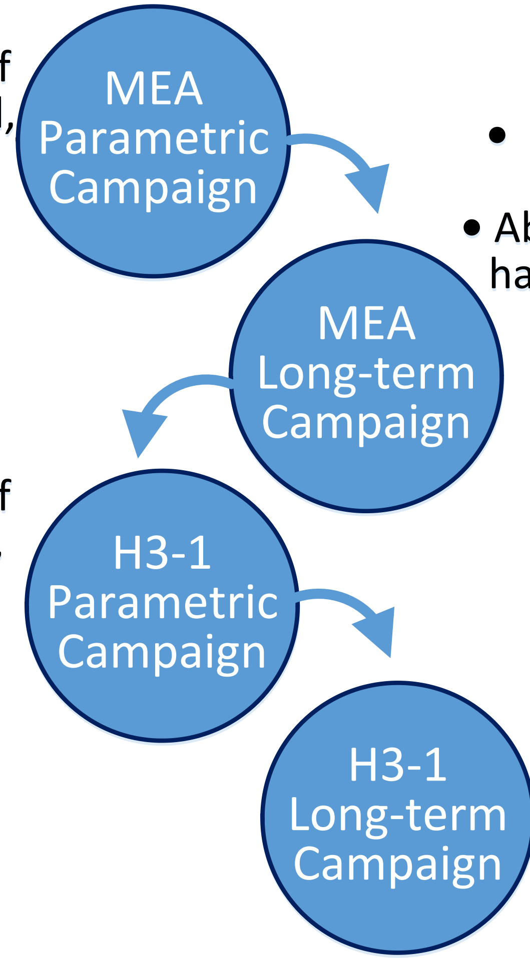
BP4: April 1, 2015 to March 31, 2017 (24 months)

Scope Addition: April 1, 2017 to March 31, 2019 (24 months)



All Criteria Met and Project Key Findings

- Process can easily capture 90% of CO_2
- Solvent regeneration energy of 1200–1750 BTU/lb CO_2-captured, ~13% lower than Reference Case 10 (RC 10)



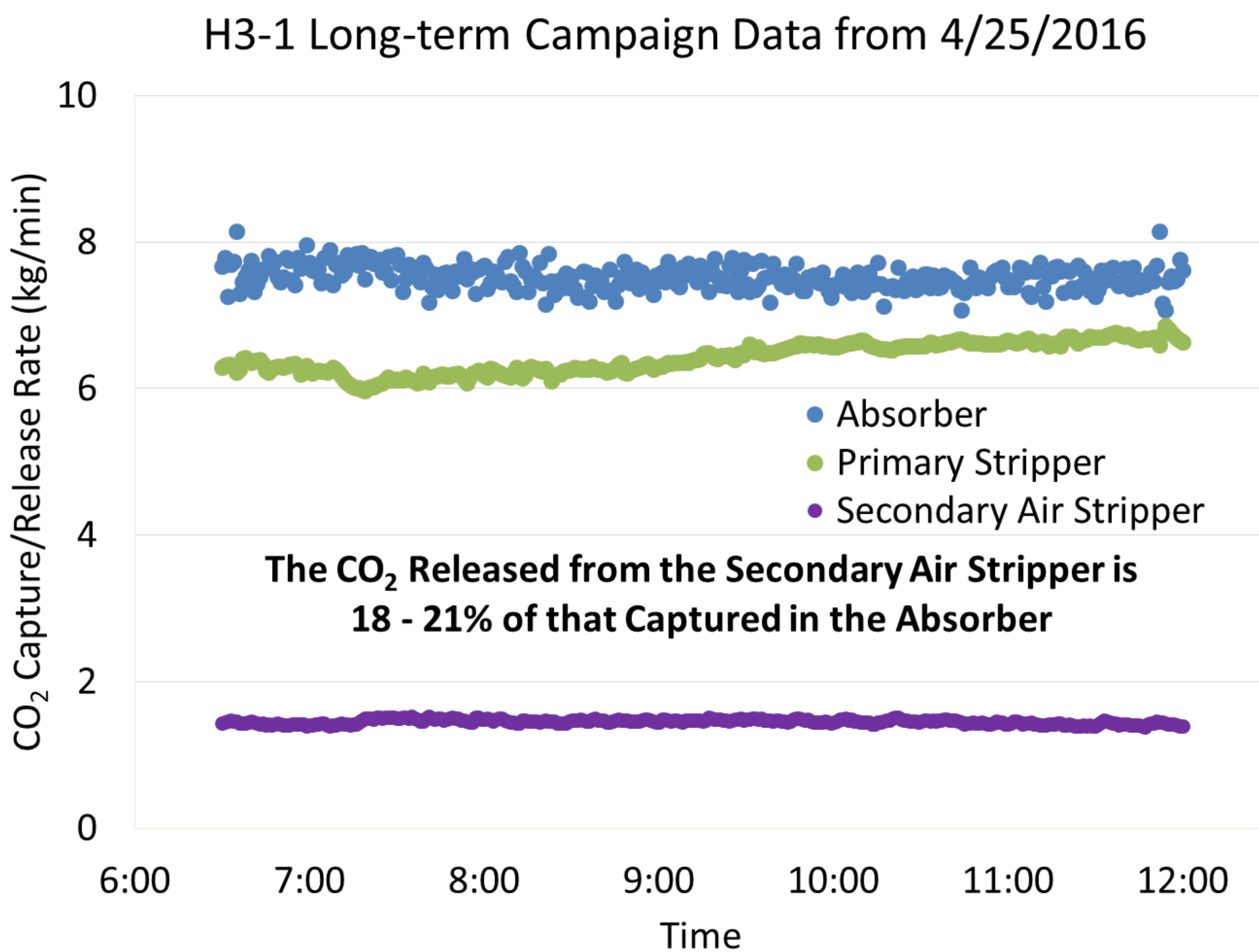
- Ambient conditions have an impact on CO_2 capture
- Absorber liquid/gas distribution has an impact on performance
- Lean/rich exchanger performance is critical
- Elemental accumulation in the solvent needs to be monitored

- Solvent regeneration energy of 900–1600 BTU/lb CO_2-captured, ~36% lower than RC10
- Secondary air stripper performs as expected

- 90% CO_2 capture and low solvent regeneration energies are possible with a range of solvent concentrations

Project Success Criteria - Achieved

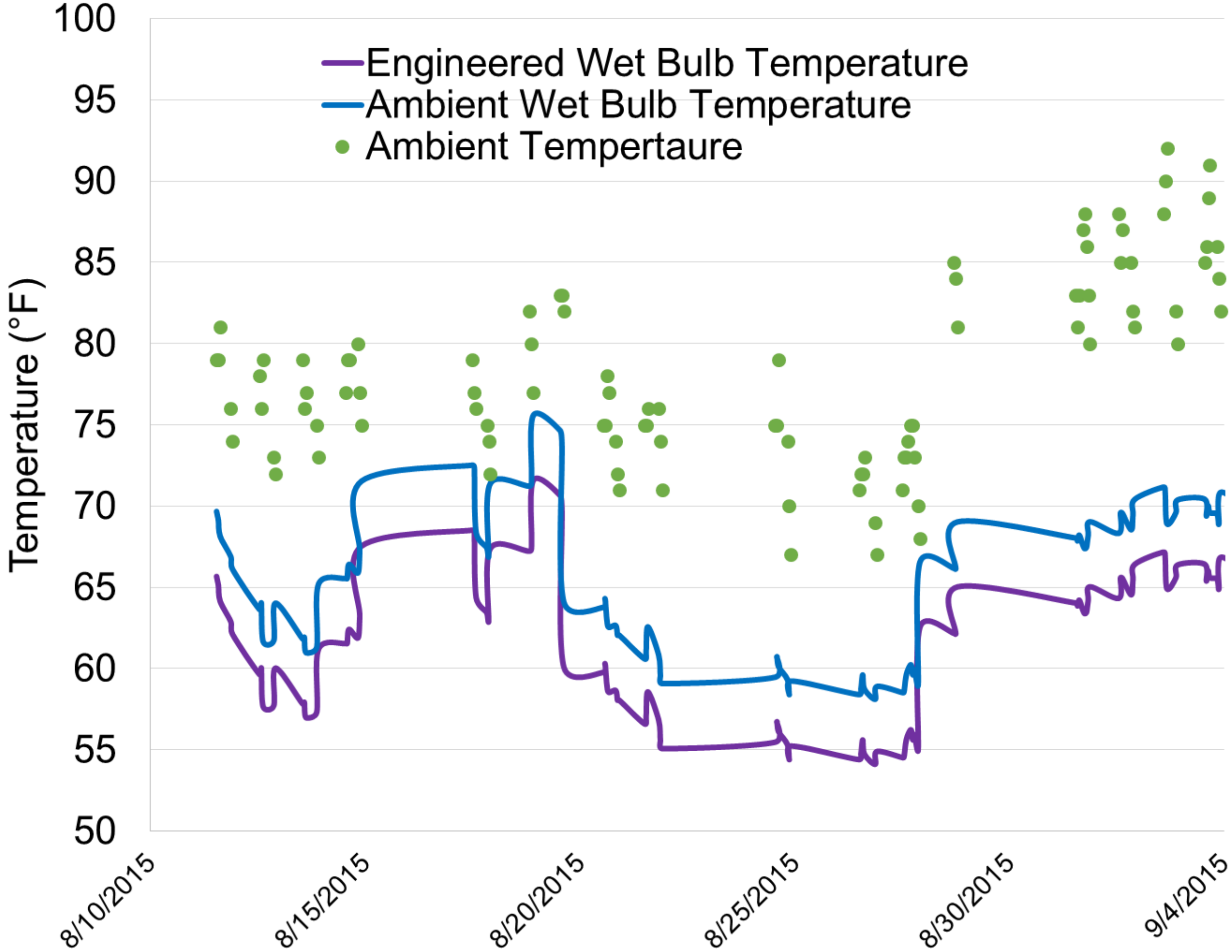
A heat-integrated post-combustion CO_2 capture system with:



Partial CO_2 recycling (10-20% of CO_2 captured) to enhance gaseous CO_2 pressure at the absorber inlet.

Project Success Criteria - Achieved

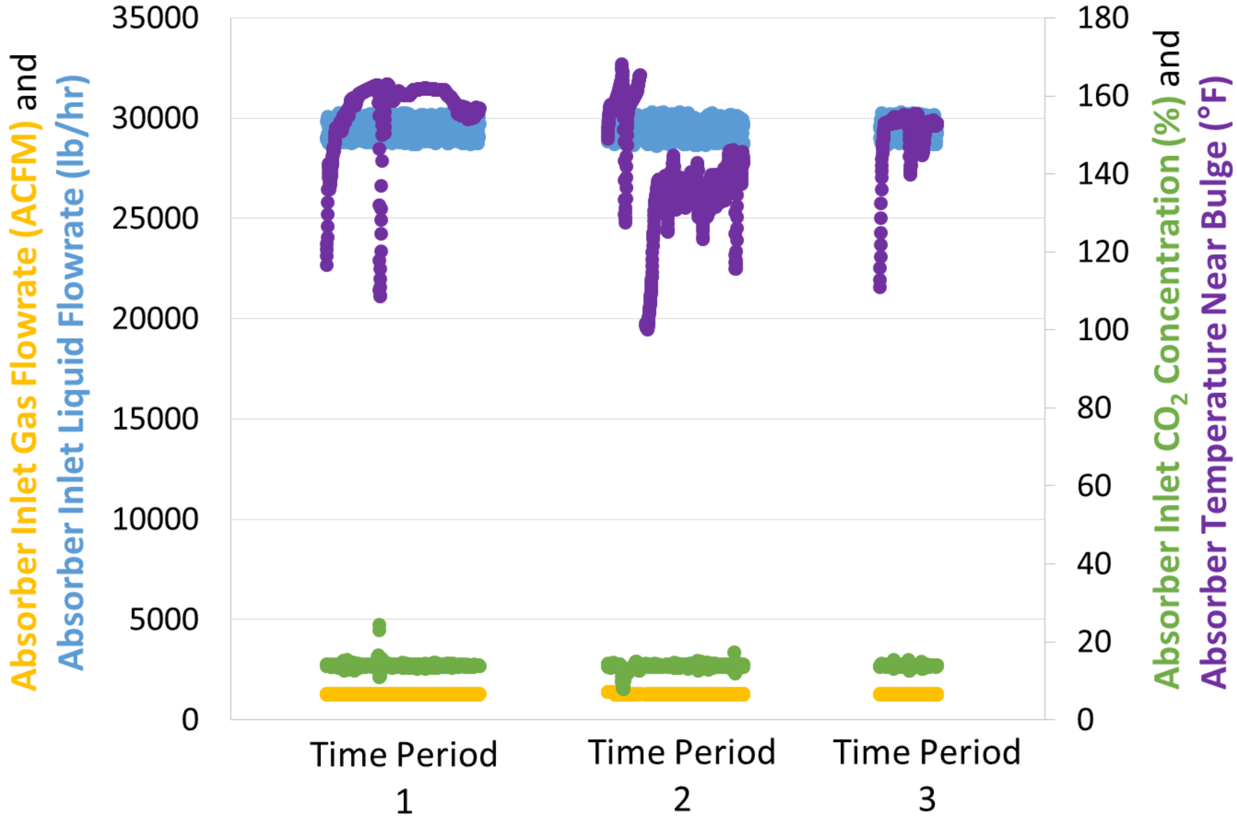
A heat-integrated post-combustion CO_2 capture system with:



Much cooler recirculating cooling water, 3-9 °F compared to a conventional cooling tower at the same ambient conditions.

Project Key Finding

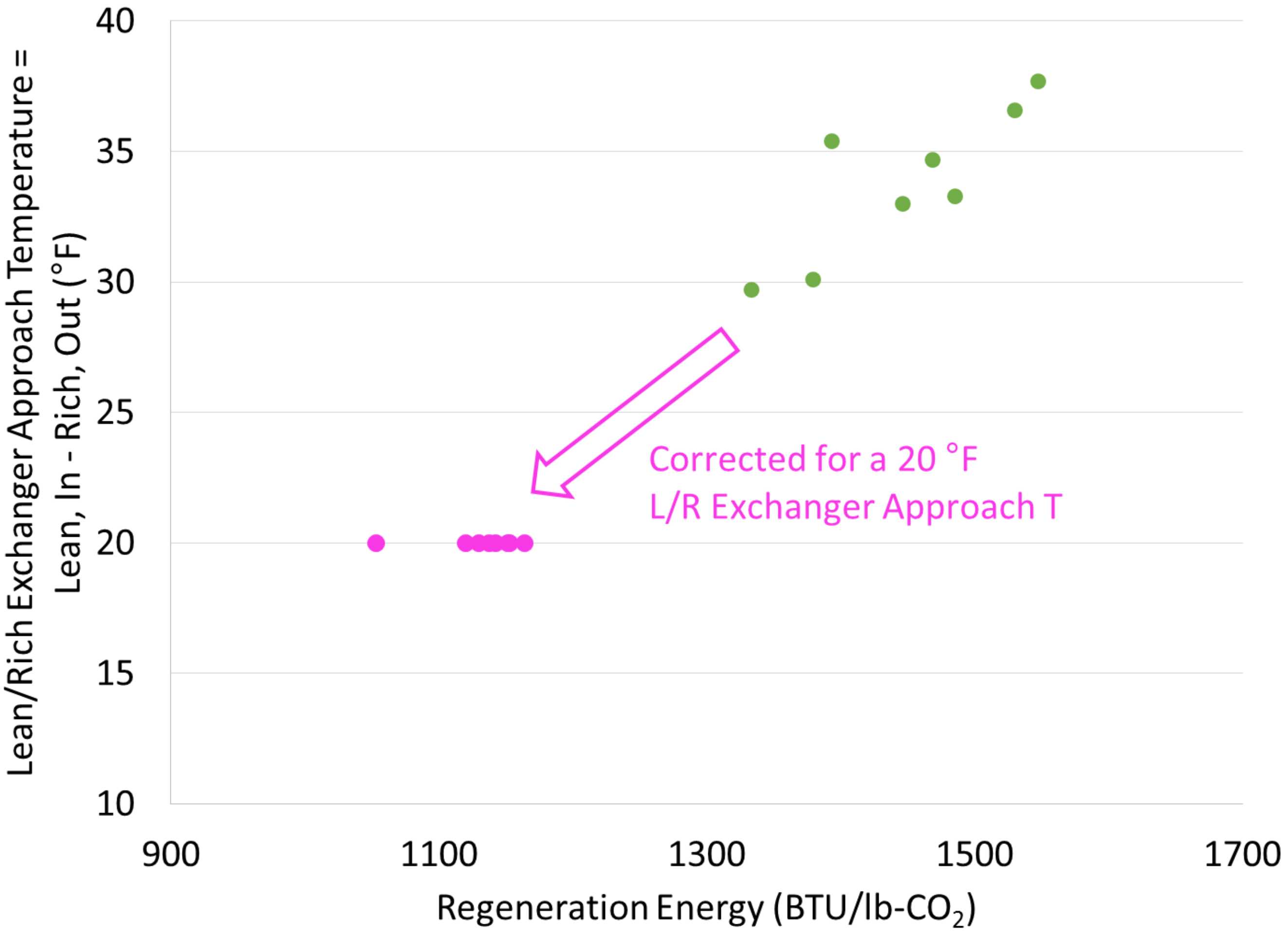
Liquid/gas distribution can significantly reduce the absorber efficiency.



Process data with constant absorber L/G, inlet CO_2 concentration, inlet amine CO_2-loading and temperature.

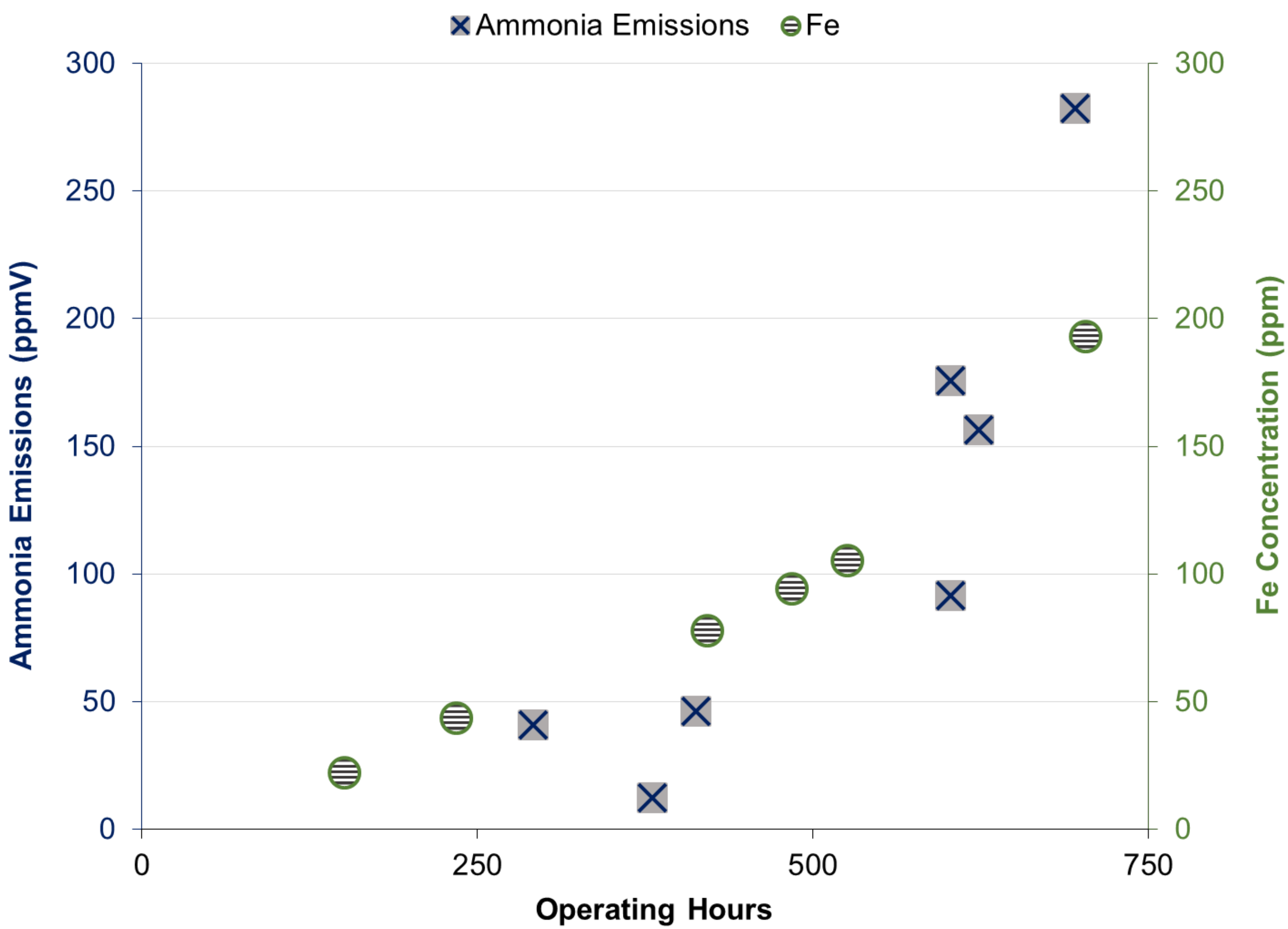
Project Key Finding

Understanding the L/R exchanger performance is critical when comparing regeneration energies.

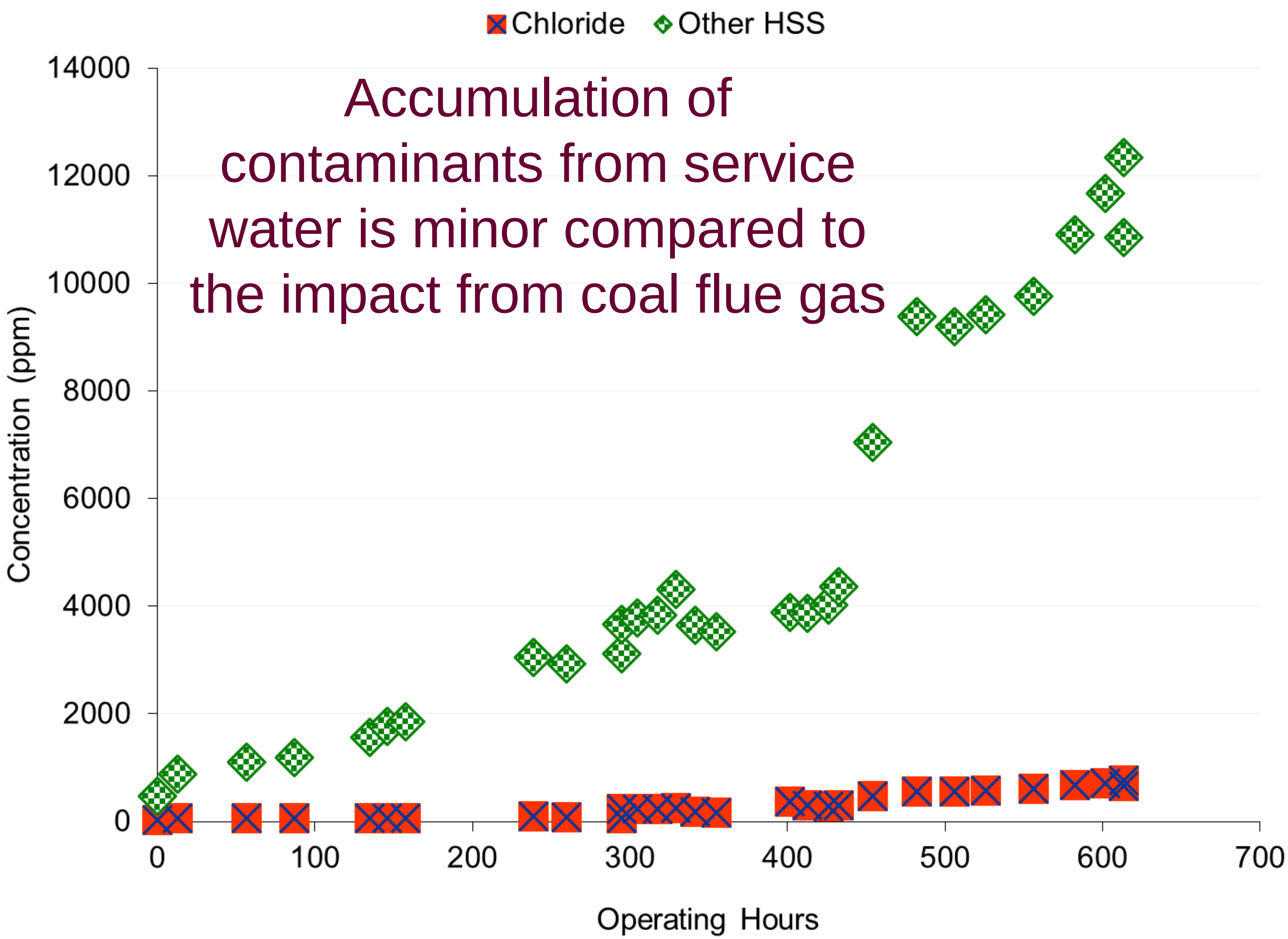


Ammonia Emissions and Iron

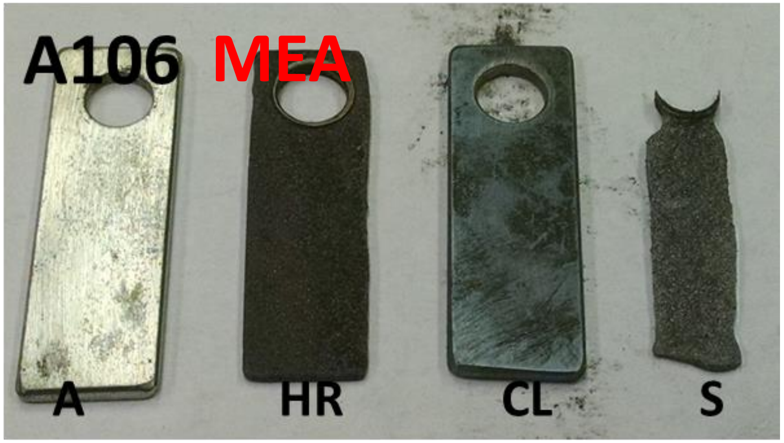
Positive correlation between NH_3 emissions and higher Fe in the solvent.

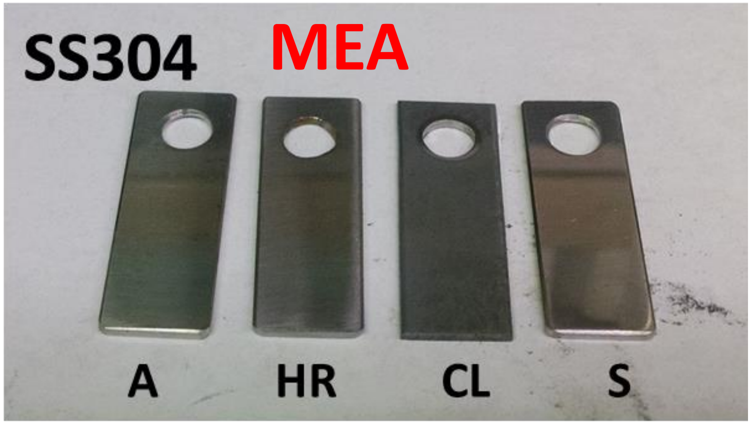


Service Water Usage

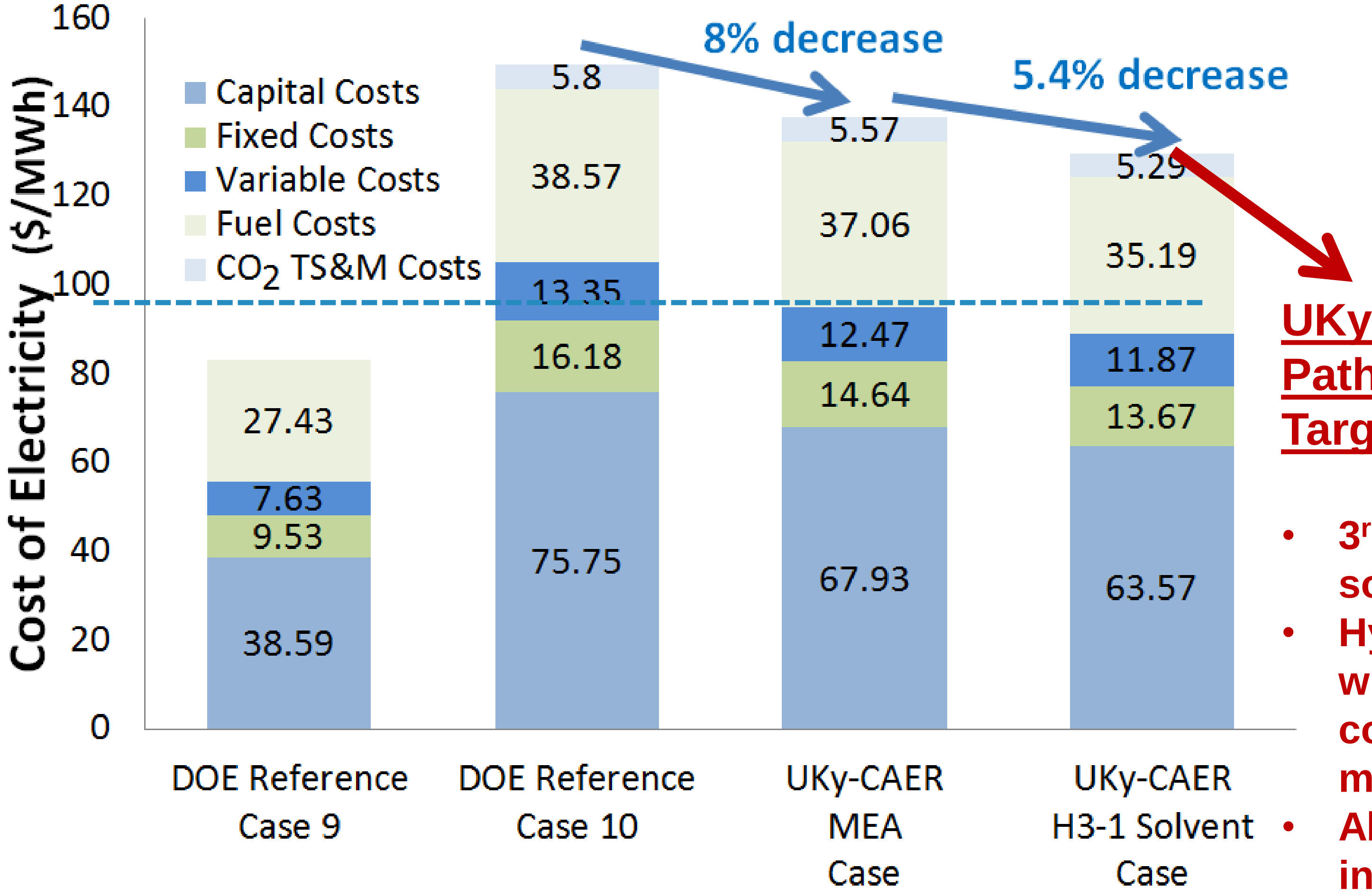


Corrosion Characterization





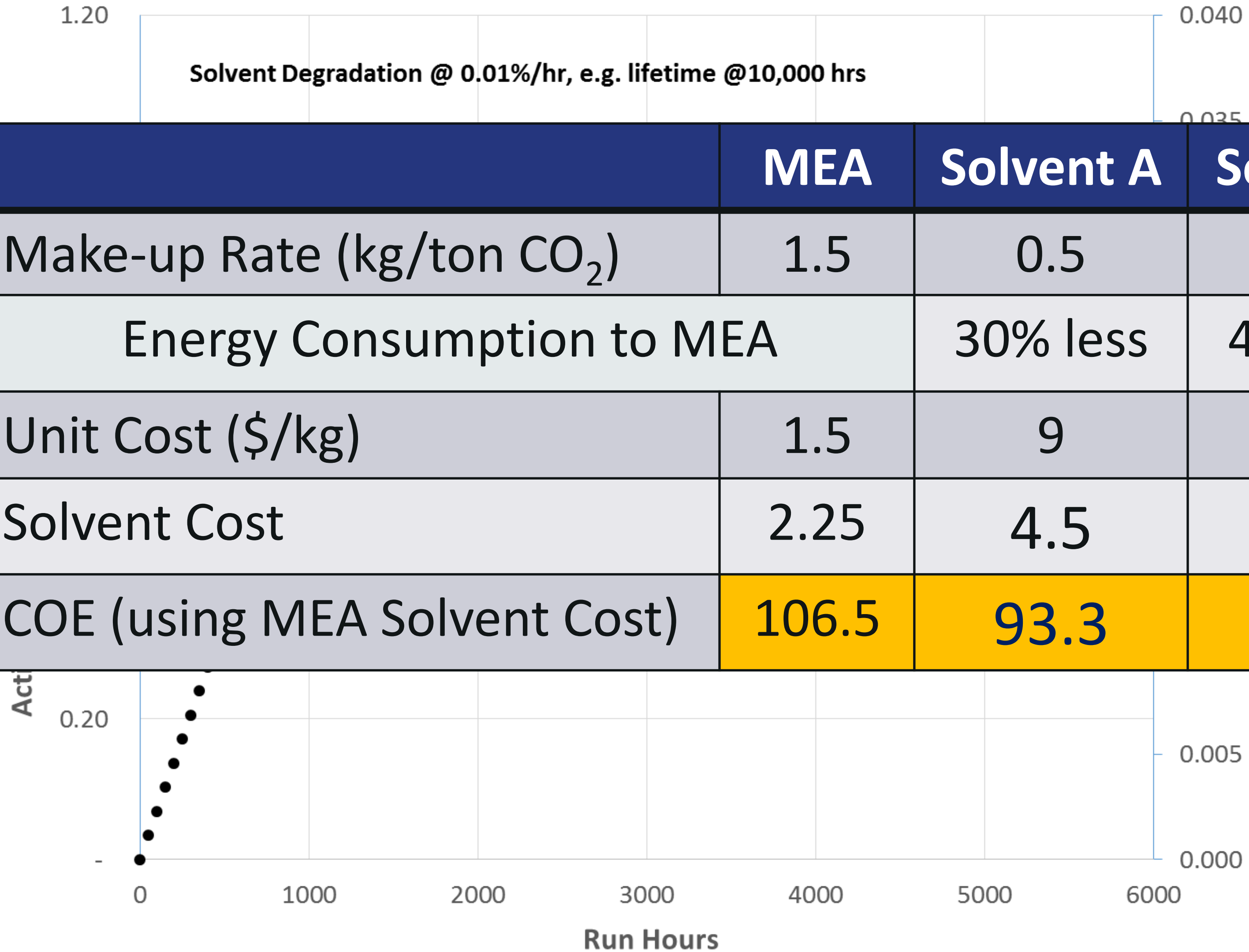
Summary of TEA (@2007$)



UKy-CAER's Pathway to Target:

- 3rd generation solvent
- Hybrid process with pre-concentrating membrane
- Absorber gas inter-conditioner

The Cost of 2nd Generation Solvents Prevents COE Reduction



	MEA	Solvent A	Solvent B
Make-up Rate (kg/ton CO_2)	1.5	0.5	0.5
Energy Consumption to MEA		30% less	40% less
Unit Cost ($/kg)	1.5	9	15
Solvent Cost	2.25	4.5	7.5
COE (using MEA Solvent Cost)	106.5	93.3	91.2

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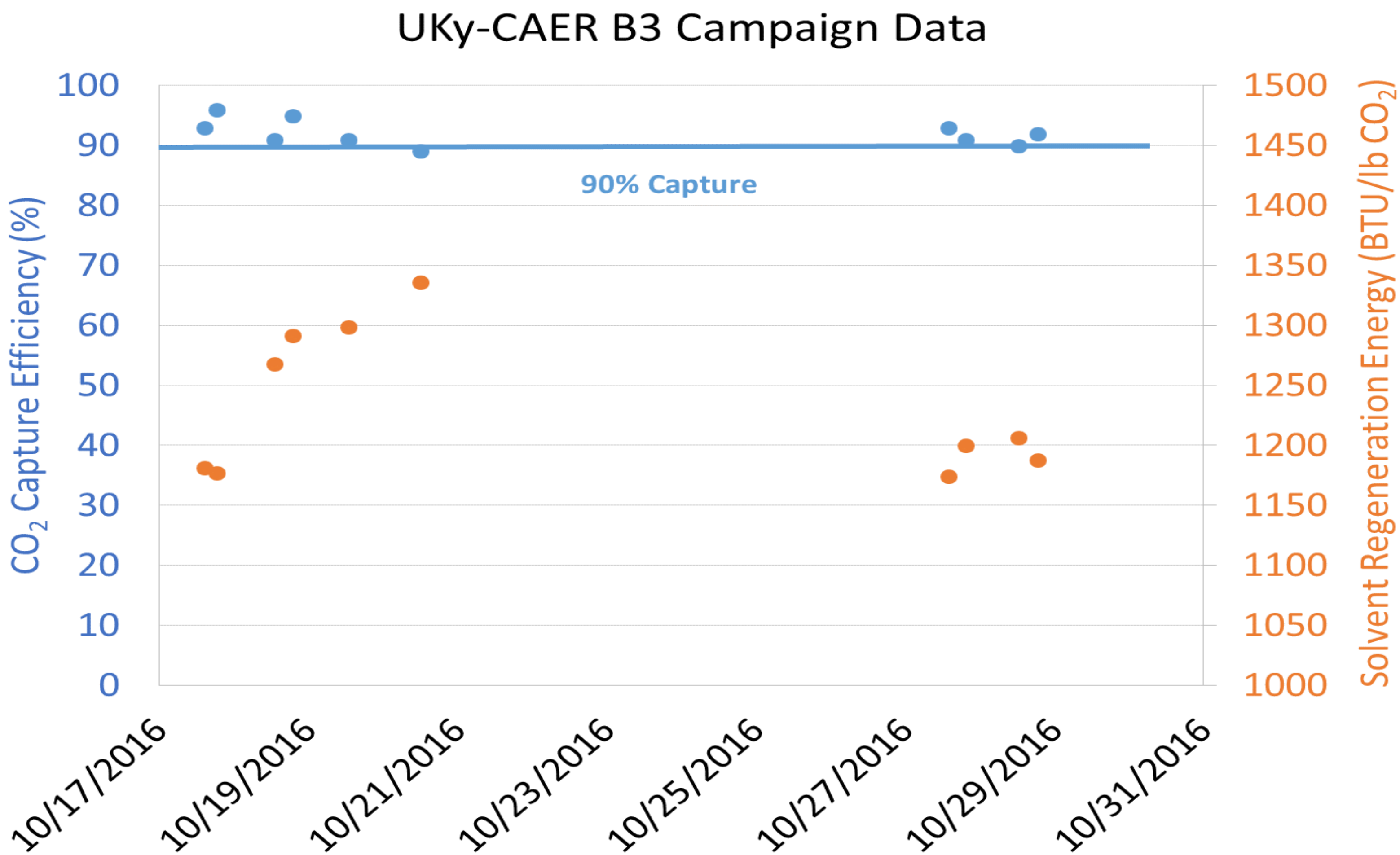
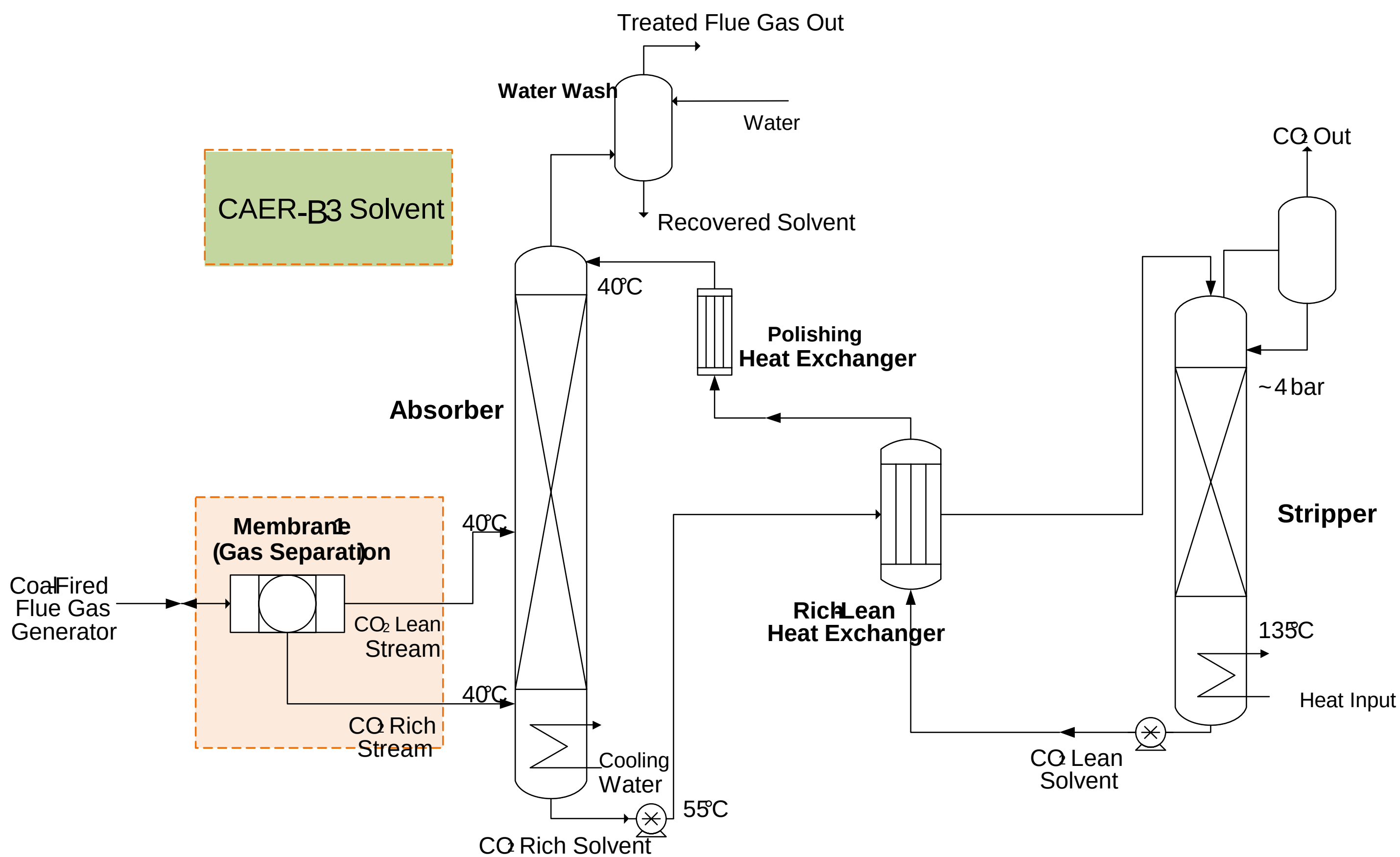
3rd Generation Solvent is Needed

- Kinetics are faster than 2nd generation, but
- 25-30% better than MEA while the cost is 2x



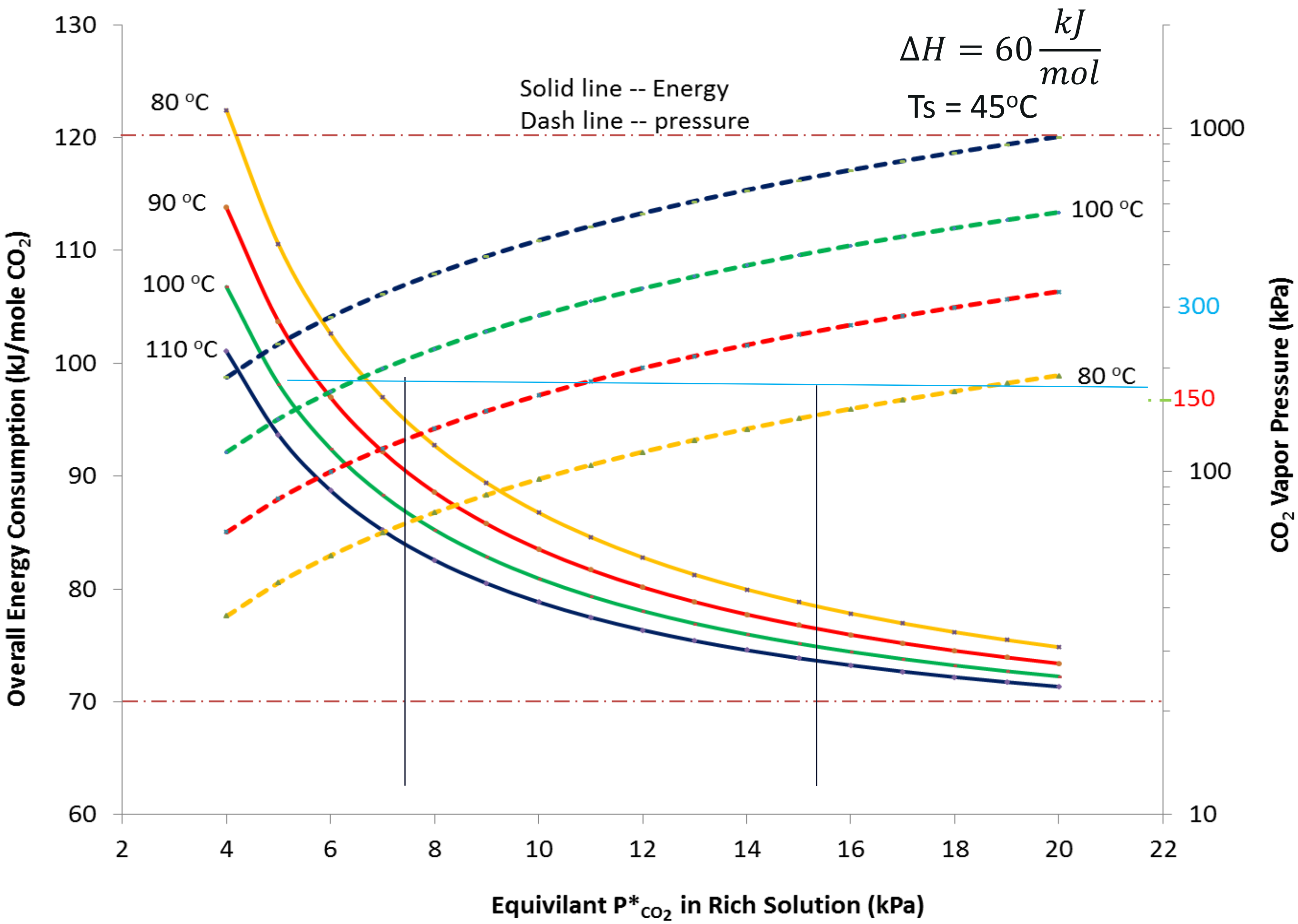
Large Bench Project Overview

- 3rd generation solvent
- Enriched carbon loading prior to solvent regenerator
  - ➢ Pre-absorber CO_2 enrichment
  - ➢ Rich Solution dewatering



Motivation

- **Driving force for high carbon loading**
- **Thermal compression at low temperature then less degradation**



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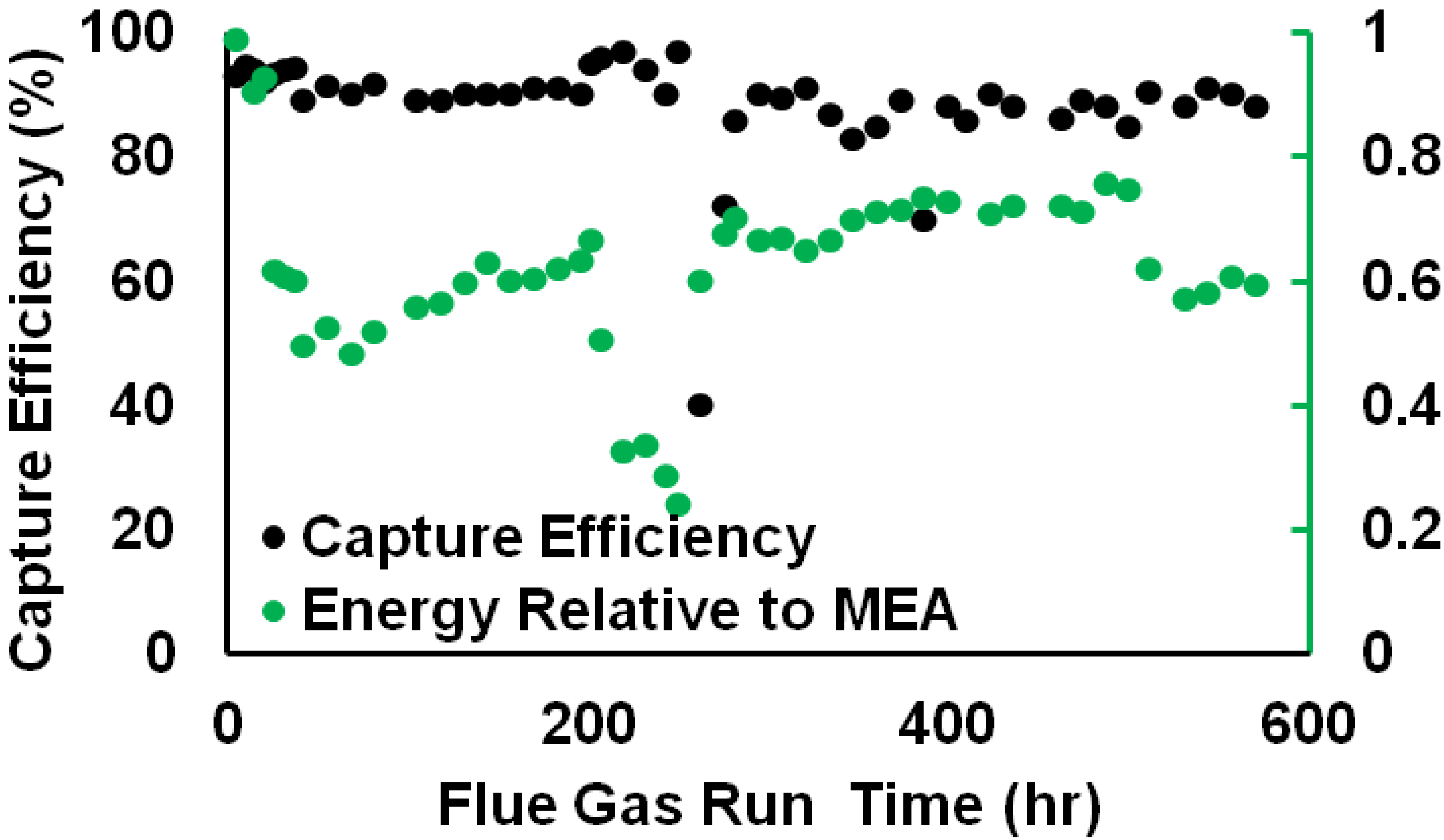
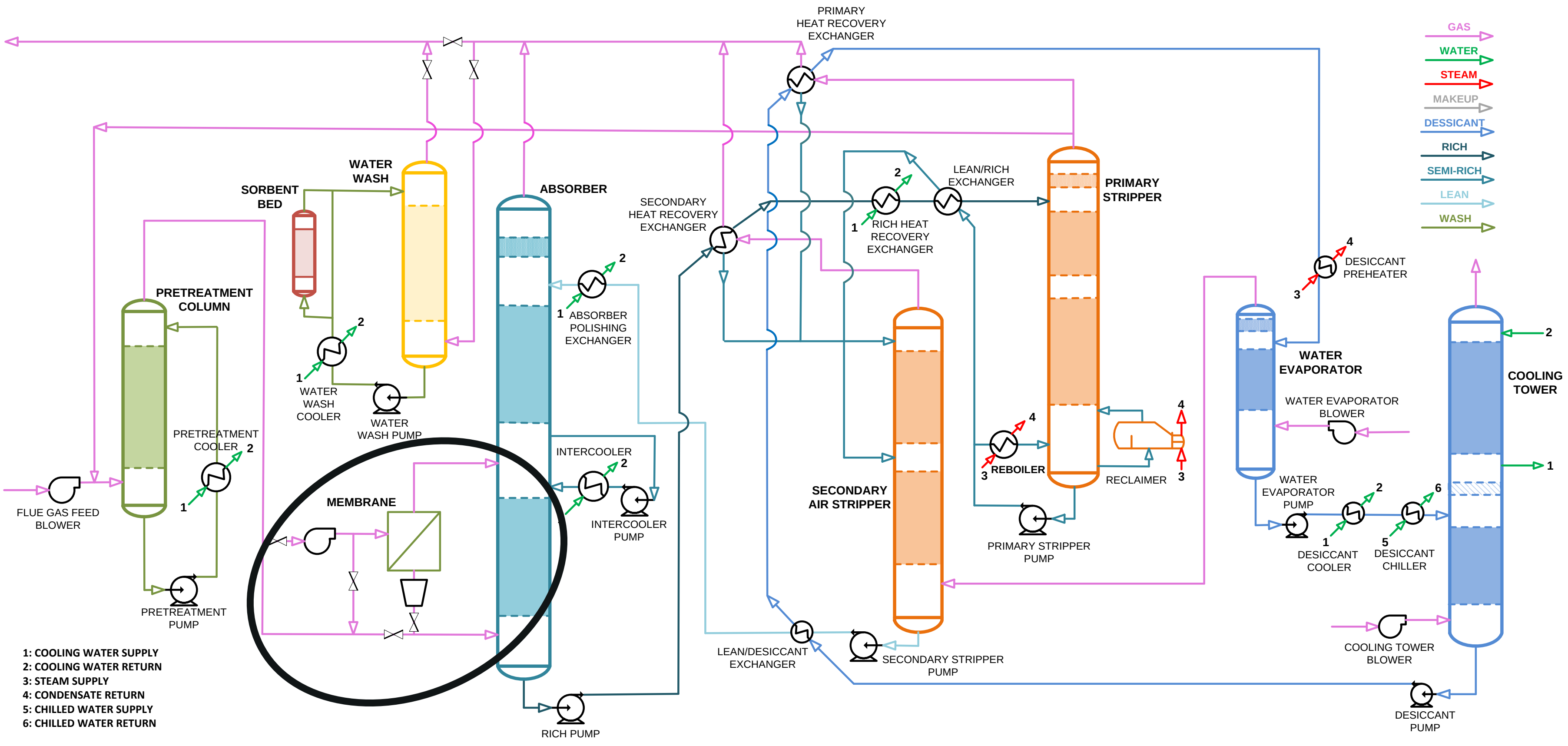
Effectiveness of Pre-concentrating Membrane



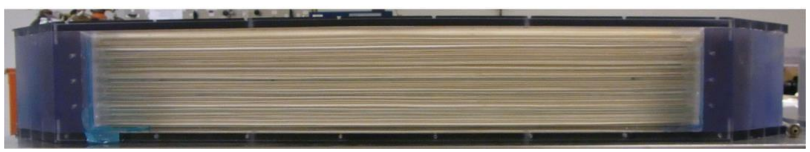
- **Solvent independent**
- **Stable performance**

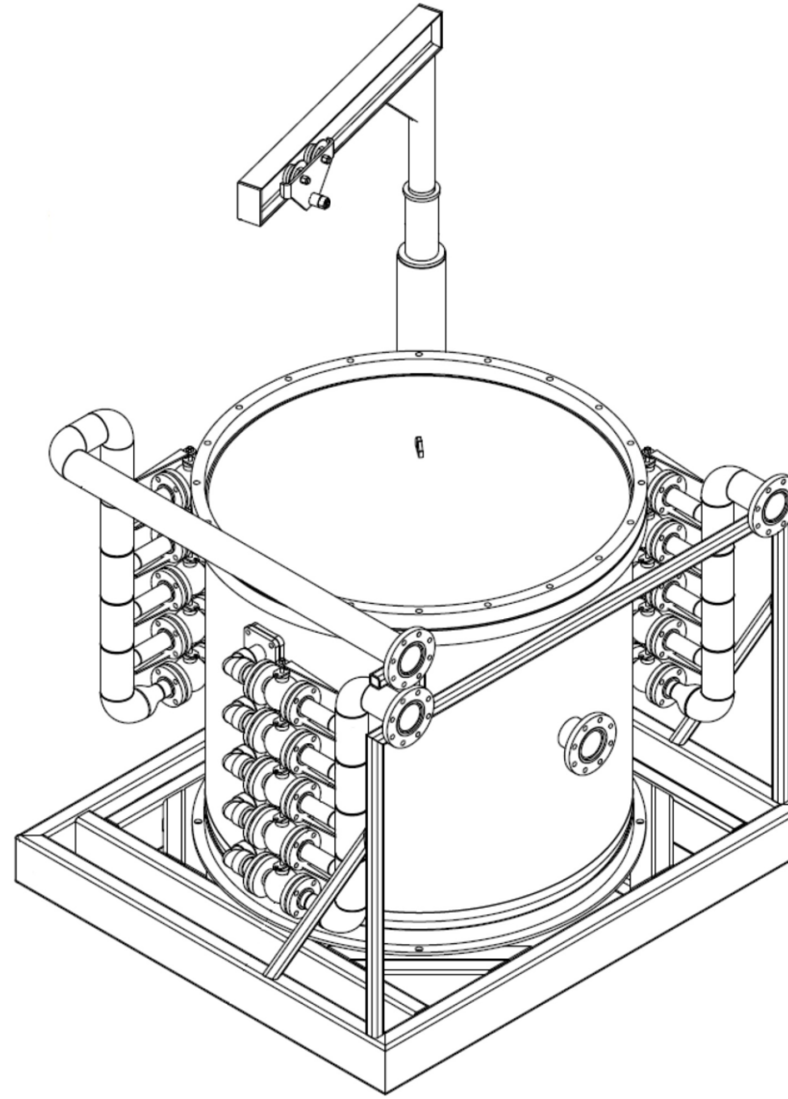
Updated 0.7 MWe CCS Flowchart for Scope Addition



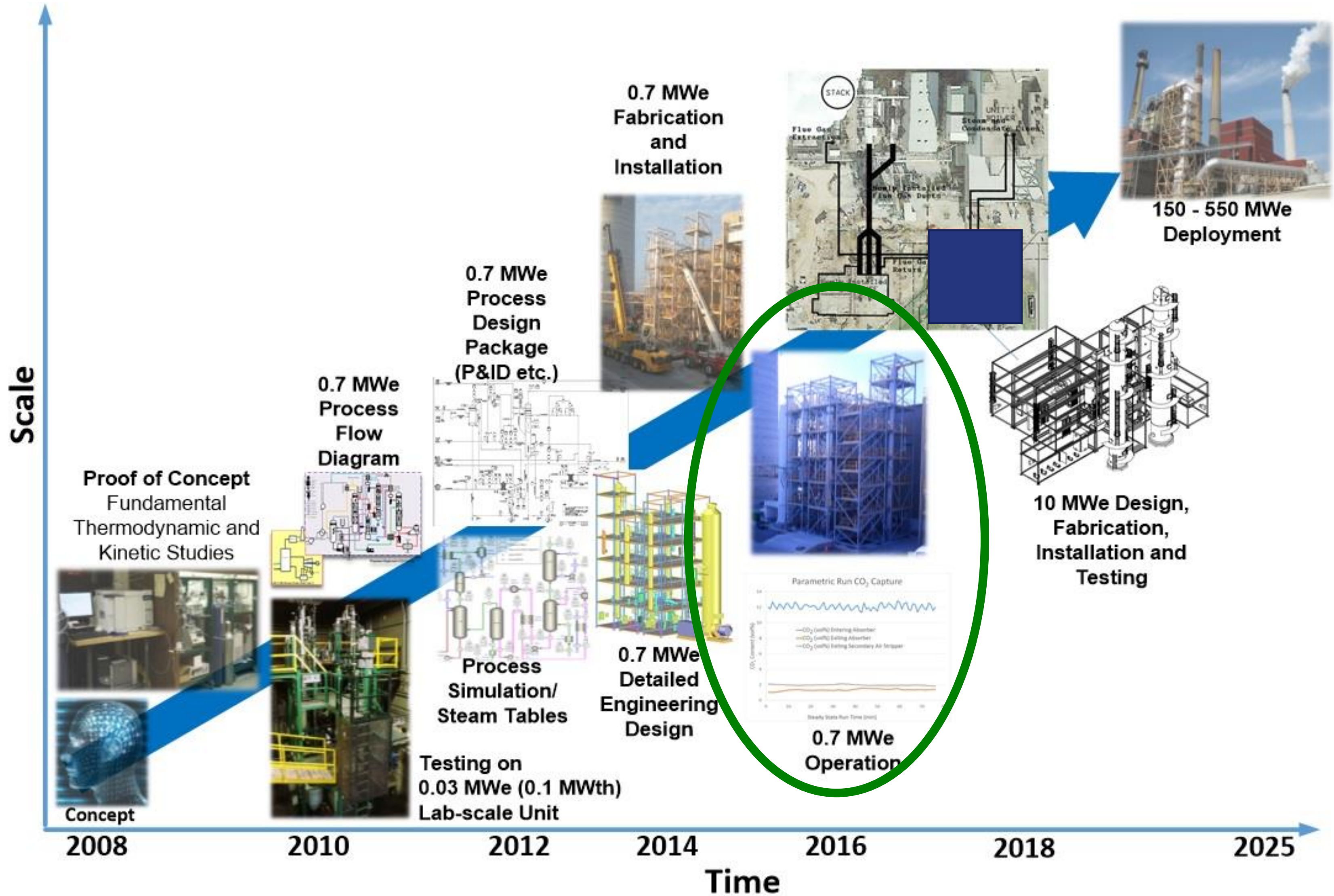
Target: ~800 BTU/lb-CO_2

CO_2 Pre-concentrating Membrane (currently using MTR Product)





Technology Development Pathway



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CMRG Members

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UKy-CAER Slipstream Team

The Slipstream Team: Kunlei Liu, Lisa Richburg, Fan Zhen, Andy Placido, Jon Pelgen, Reynolds Frimpong, Amanda Warriner, Len Goodpaster, Marshall Marcum, Otto Hoffmann, Leland Widger, Jonny Bryant, Brad Irvin, James Landon, Wei Li, Jesse Thompson, Saloni Bhatnagar, and Keemia Abad