UKy-CAER Heat-integrated Transformative CO_2 Capture Process in Pulverized Coal Power Plants

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

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Executive Summary

- Process oriented technology
- Applicable with any 2nd generation solvent
- All sub-technologies/ approaches have been proven
- Experienced team assembled
- Ongoing relationship with host site utility
- Firm financial commitment received from State of Kentucky (Executive Branch and Legislators), University senior management and utilities

	Technical Achievement	UKy-CAER History of Experimentally Demonstrated Success
Process Intensification	CO_2 Recycling	2012 Bench, 2015-2017 Small Pilot
	Discretized Packing Selection	Common Industrial Distillation Practice, 2013 Modelling, 2017 Bench for CO_2 Capture
	Pump Around	2009 Bench, 2015-2017 at Small Pilot
	Solvent Recovery System	2015 at Bench, 2018 Small Pilot (planned)
	Advanced Solvent	2013-2017 Bench, 2015-2017 Small and Large Pilot
System Integration & Heat Recovery	Two-stage Stripping	2010 Bench, 2015-2017 Small Pilot
	Pressurized Primary Stripper with Split Rich Solvent Feed	2008-2017 Bench, 2015-2017 Small Pilot, 2014 Modelling, 2015-2017 UTA Small Pilot
	Exergy Loss Minimization	2015 Modelling
	Smart Controls	2016-2017 at Small Pilot
	Hybrid System	2014 Bench, 2018 Small Pilot (planned)

Name	Role	Year Partnering with UKy
LG&E-KU	Host site	2005
KMPS	ISBL	2009
WP	OSBL	2011
CCSL	Solvent Supplier	2013
EPRI	TEA and 3rd Verfication	2008
SMG	EIV	2010
HCERI	Engineering Aspect	2010
UT	Solvent & Emission Aspect	2008
Trimeric	Cost and Engineering Audit	2010

Project Overview
Funding (DOE and Cost Share) and Project Performance Dates

Project Funding Profile			
Funding	Government Share	Cost Share	Total
Total	$941,997	$235,553	$1,177,550
Cost share %	80.00%	20.00%	100%

04/01/18 to 07/31/19

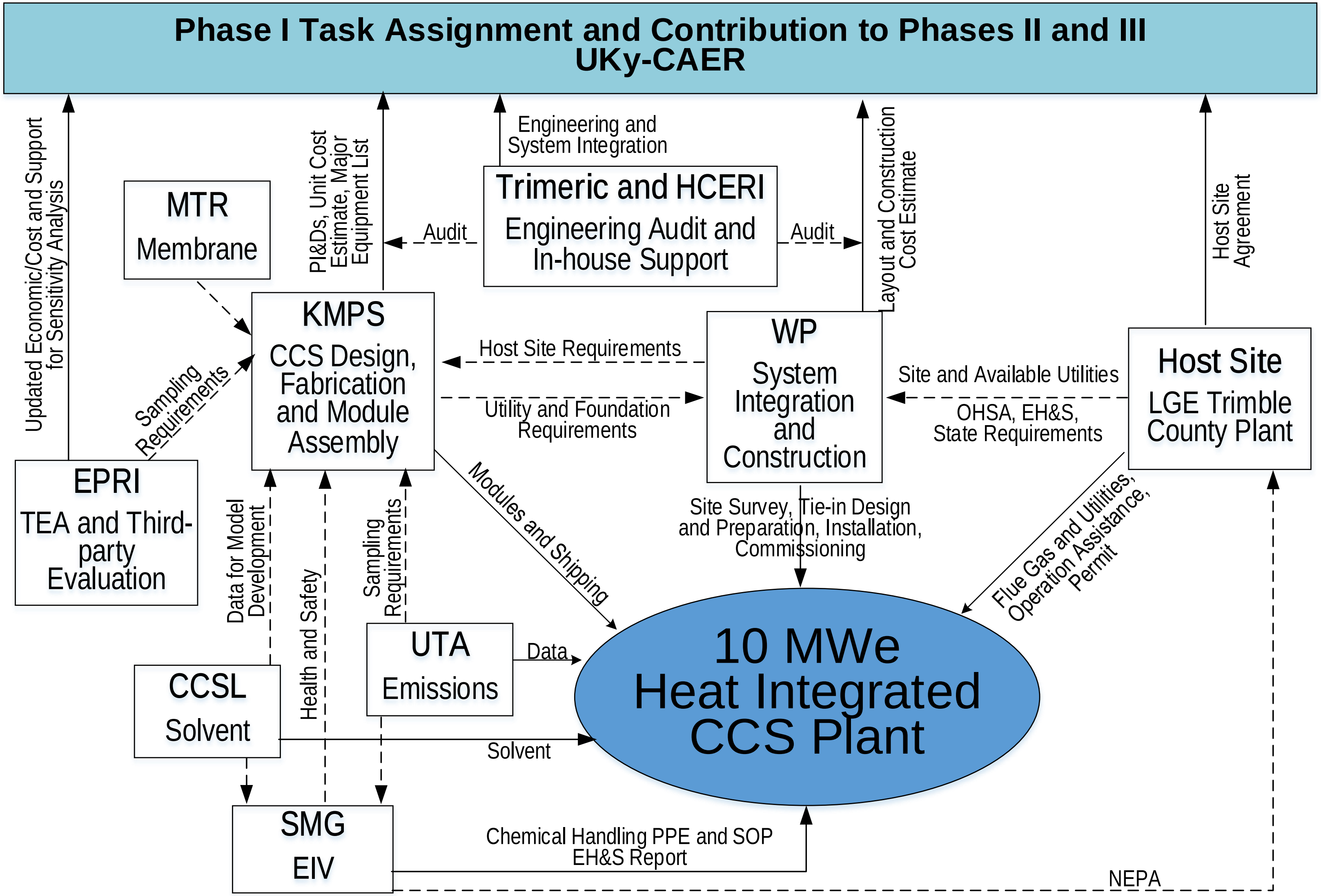
16 Months in Duration

One Budget Period

Phase II Application Due 3/31/2019

Project Overview

Project Participants and Responsibility



Project Overview

Overall Project Objectives

Advance the UKy-CAER post-combustion CO_2 capture technology, demonstrating an achievable COE with CCS of < $30/tonne CO_2 captured when natural gas is used to provide CCS electricity and steam

Phase I Goals

1) Reinforce the cohesive project team including technology development; solvent development; EH&S; engineering design, fabrication, and construction management; technology commercialization and end-user utilities

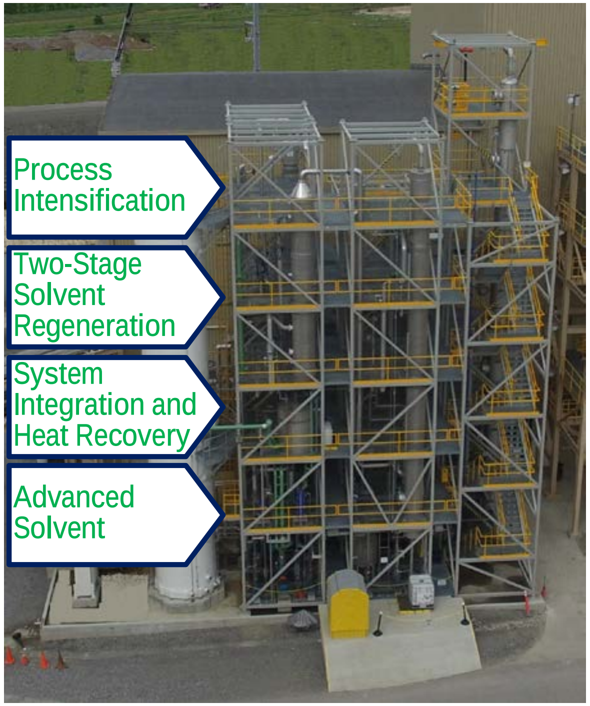
2) Select and secure a host site and CCS location

3) Update H&M balances with most recent small-scale experimental data and chemical composition to complete and improve accuracy of an EIV and process design package, including the cost and schedule

4) Secure commitments from a process design firm, NEPA contractor, technology partners and vendors

5) Update Phases II and III preliminary costs and schedules

6) Secure commitments for Phases II and III cost share



Technology Background

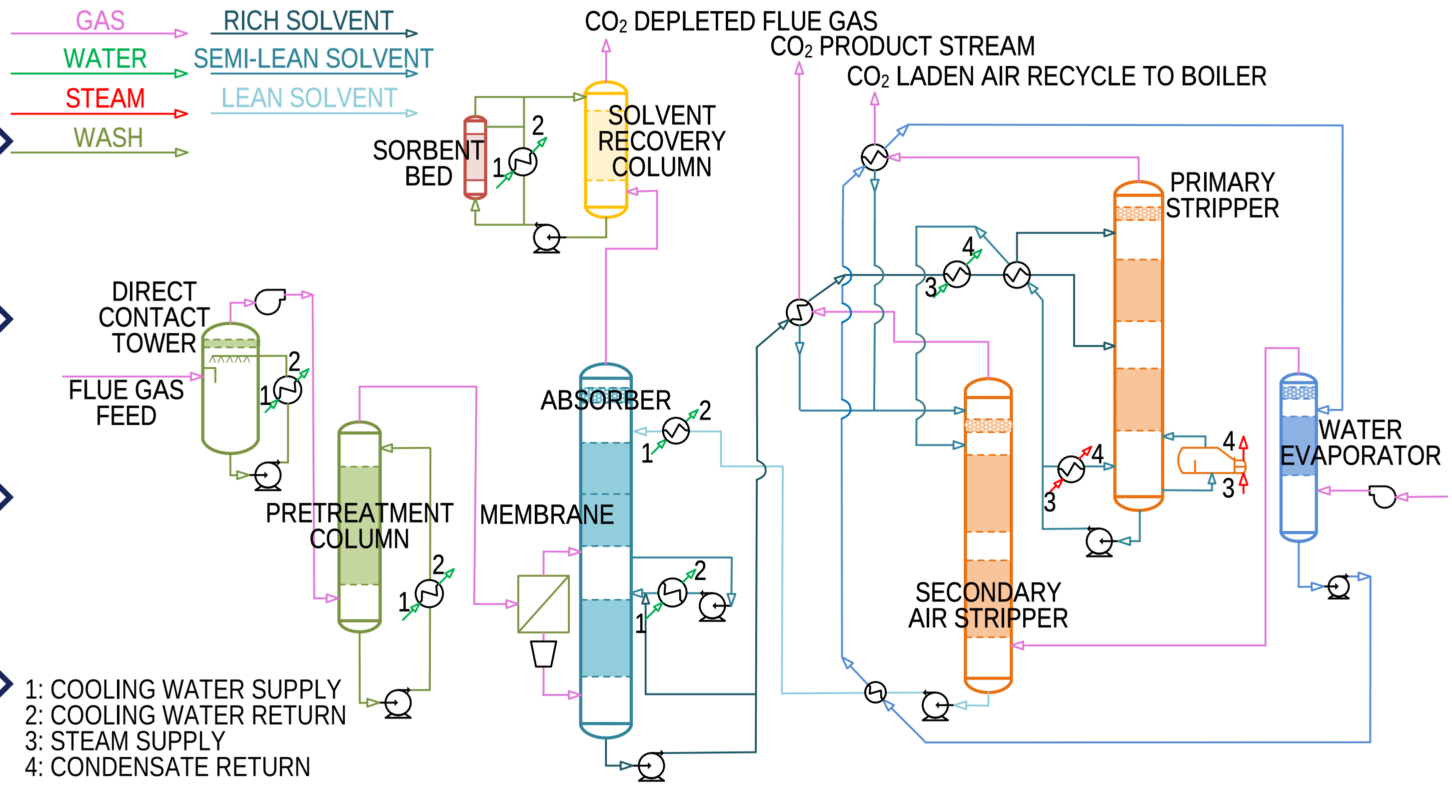
UKy-CAER CO_2 Capture Technology

Process Intensification

Two-Stage Solvent Regeneration

System Integration and Heat Recovery

Advanced Solvent



A Confirmed Heat Integrated PCCC Technology

Robustness Advantage

Versatile

Four solvent campaigns complete with the fifth underway

Stable

Steady state at 90% capture achievable within 2-3 hours after a cold startup

Demonstration of amine concentration maintenance and water balance between liquid desiccant and amine loops

Flexible

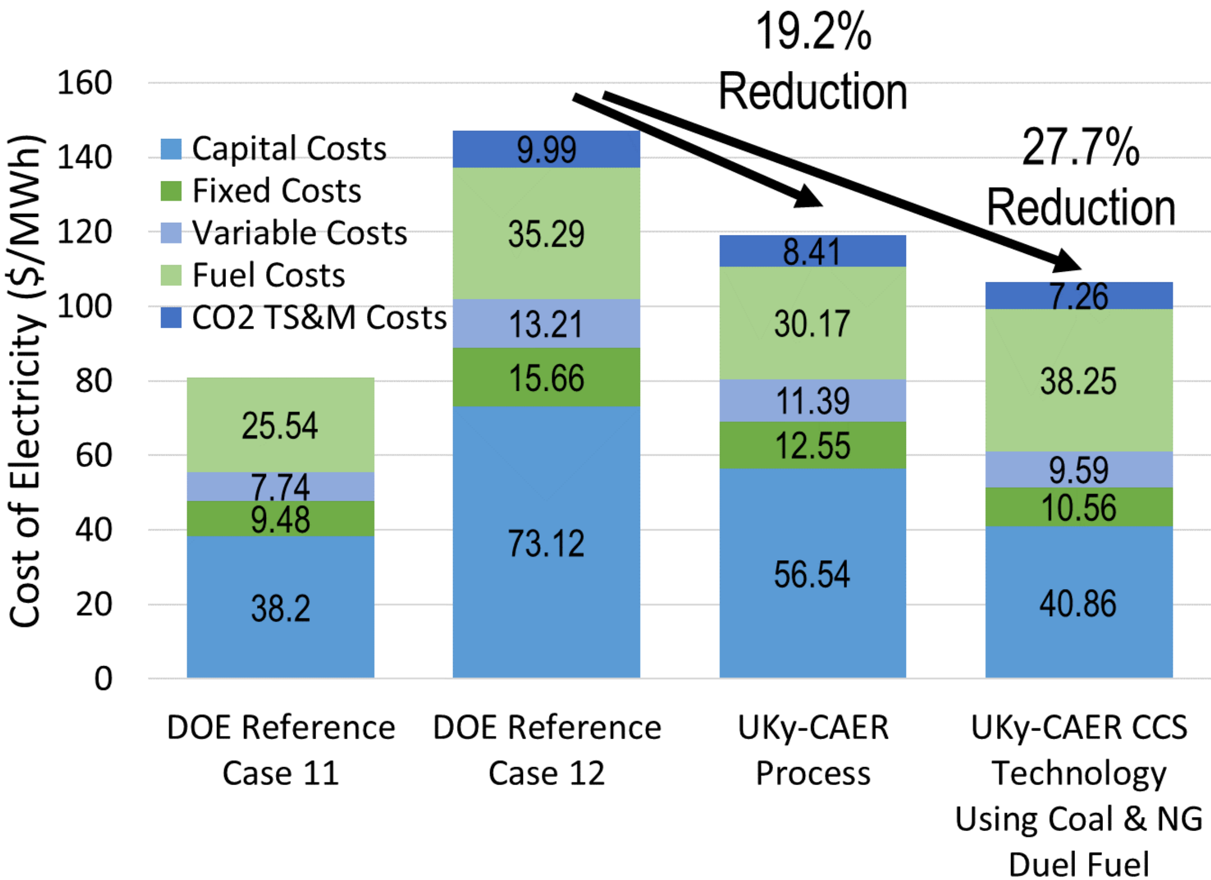
Typical operations include daily process start-up and shut down with 24-hour per day, 7-day per week operations demonstrated

89% trouble-free startups in 2016 during non-freezing weather

85% trouble-free startups in 2017 during non-freezing weather

Technology Background

Low Cost Advantage



The Uky-CAER CCS process with an advanced solvent can deliver:

- COE of $119.07/MWh
- Cost of CO_2 captured at $34.51/tonne, excluding TS&M

With a duel fuel system, UKy-CAER technology can deliver:

- COE of $106.52/MWh
- Cost of CO_2 captured, excluding TS&M, of $25.26/tonne CO_2

All at 90% coal flue gas capture rate and CO_2 compression to 2200 psia.

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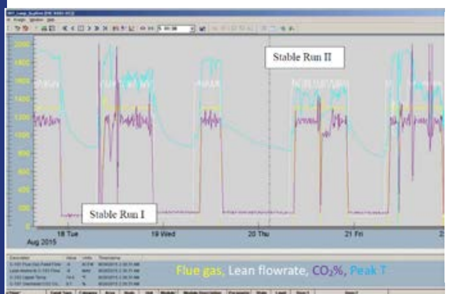
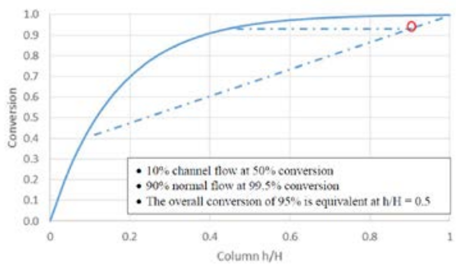
Technology Background

Challenges We Will Address

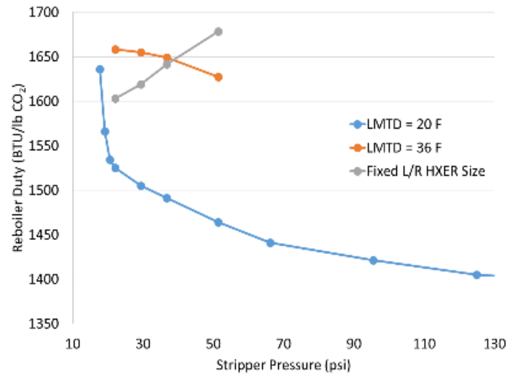
Absorber Liquid/Gas Distribution and Redistribution





Absorber performance is significantly reduced with liquid/gas maldistribution.

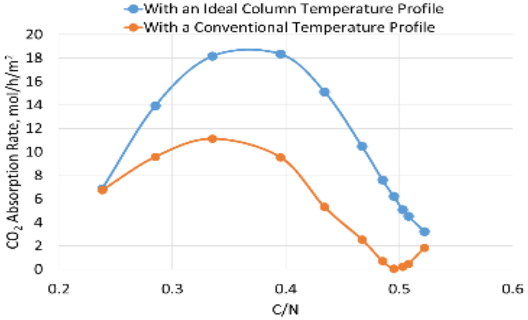
Thermal Compression and L/R Exchanger Size



Benefits associated with thermal compression reducing the H_2O/CO_2 ratio at the stripper outlet, lowering the reboiler duty are not realized if the L/R exchanger is not properly sized.

Waste Quantity Minimization

Absorber Effectiveness and Column T Profile



With an ideal column temperature profile, the average CO_2 absorption rate can be increased significantly.

Technical Approach/Project Scope

Experimental Design and Work Plan

2000+ Operational Hours

Air Emissions

Amine loss and gas emission evaluated to update commercial scale emissions species and volume estimates

Maintaining Solvent Quality

Heat stable salt formation

RCRA element accumulation

Reclaiming effectiveness

Waste minimization

Corrosion

Lower cost materials evaluated with/without non-metal coatings

Advanced Controls

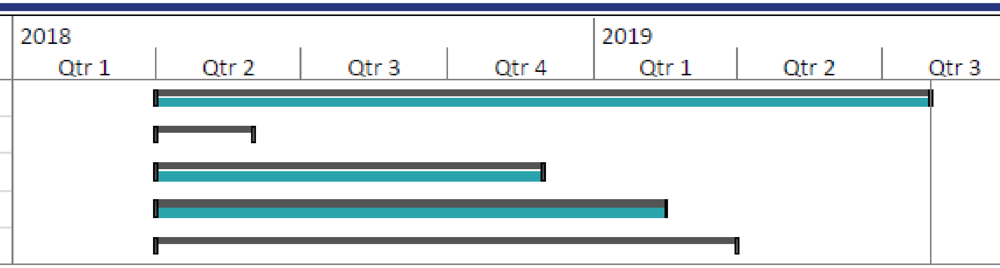
Fast response variables, such as the CO_2 product flow paired with the absorber gas-side calculated CO_2 capture efficiency

Model predictive control

Technical Approach/Project Scope

Project Schedule

Task Name	Start
1 Project Management and Planning	**Sun 4/1/18**
2 Host Site Agreement Amendment	**Sun 4/1/18**
3 Aspen Plus®Model Simulation Creation and Update	**Sun 4/1/18**
4 Project Schedule and Cost Estimate	**Sun 4/1/18**
5 Environmental Information Volume	**Sun 4/1/18**



Technical Approach/Project Scope

Key Milestones

1. Multi-party NDA in Place
2. Host Site Agreement Amended
3. Completed EIV
4. Phase I Topical Report Complete

Project Success Criteria

1. A commercial scale CCS model integrated with the power generation unit model using the CCSL solvent with good agreement with the UKy-CAER 0.7 MWe small pilot experimental data.
2. An EIV identifying and estimating all potential waste stream emissions (gas, liquid, solid) from the 10 MWe large pilot facility and solvents, an assessment of the emissions properties for safety, handling, and toxicology, and an accidental release procedure for the large pilot facility.
3. Confirmation that schedule and cost will meet or exceed initial estimates.

Technical Approach/Project Scope

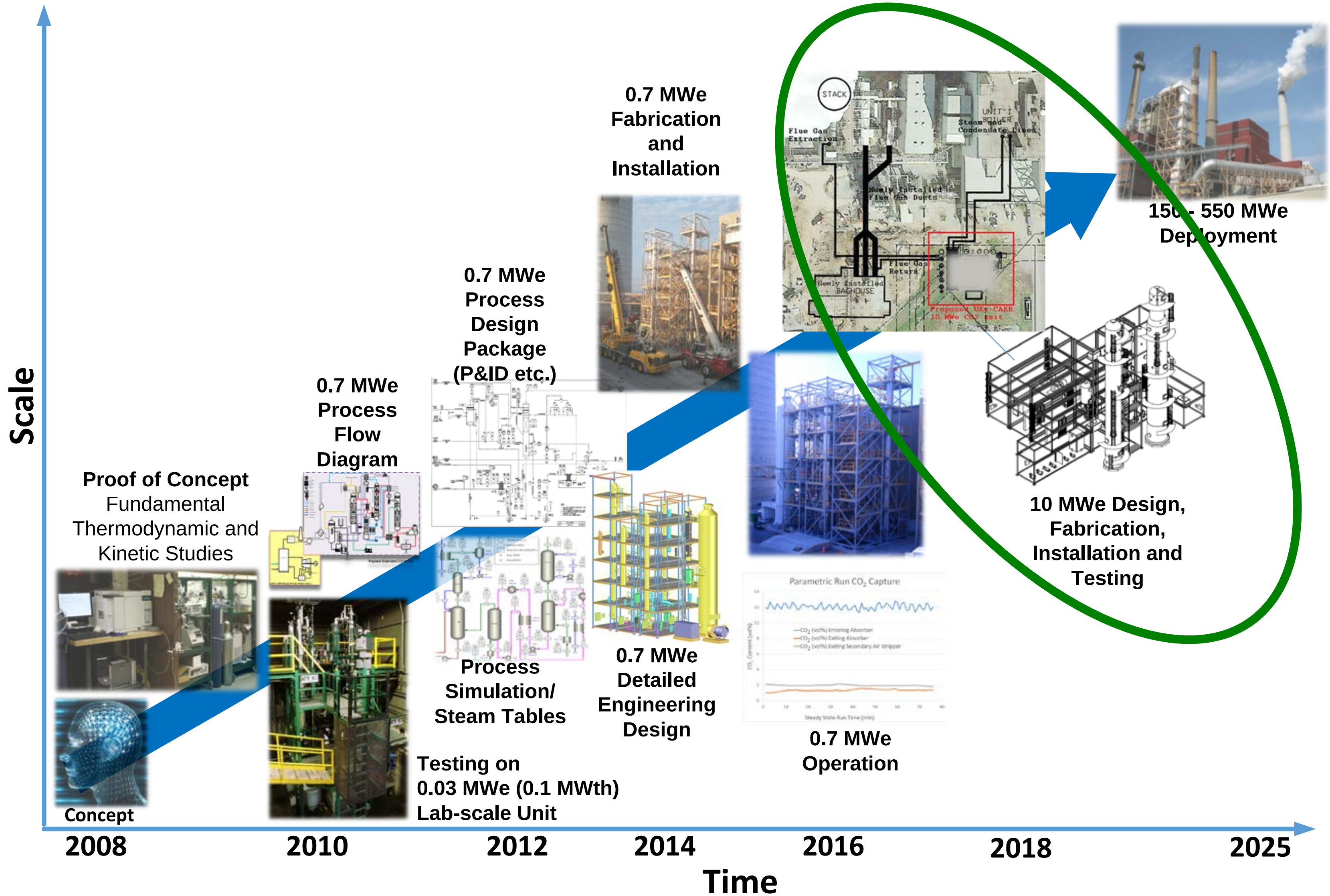
Project Risks and Mitigation Strategies

Phase I Risk Assessment, Management Mitigation and Response Strategies.			
Description of Risk	Probability (Low, Moderate, High)	Impact (Low, Moderate, High)	Risk Management Mitigation and Response Strategies
Phase I Management Risks			
Subcontract Agreement Delay	Moderate	Moderate	Dedicated UK staff will be identified.
Subcontractor Financial Stability	Low	Moderate	Alternate subcontractors will be identified.
Phase I Resource Risks			
Host Site Withdraws Support	Low	High	Several host sites have expressed interest in partnering with UKy-CAER for the large pilot project in addition to LG&E and KU. If necessary, UKy-CAER will continually seek new candidates.
Solvent Supplier Withdraws Support	Low	High	The UKy-CAER CCS is flexible enough to use most advanced solvents. While the CCSL solvent is the prime solvent for the project, two alternative solvents with suppliers on the project team have been identified to mitigate risk to the project: the HCERI and the CAER solvents.
Phase I Technical Risks			
Environmental Impact	Low	Moderate	An alternative solvent will be used or a system modifications will be made, depending on the environmental problem identified.
Process Model does not Accurately Reflect Solvent Properties	Low	Moderate	The CCSL solvent has been successfully modeled with ProTreat® and this will be used as an alternate modeling software.

Progress and Current Status of the Project

- ✓ Team Assembled
- ✓ TAB Membership Invitations Extended
- ✓ Multi-party NDA in Place
- ✓ Aspen Plus® Thermodynamic Model of the CCSL Solvent Complete
- ✓ Aspen Plus® Model of Process Complete
- ✓ ISBL Preliminary Design and Cost Estimate on Schedule to be Complete by 2/2019
- ✓ OSBL Preliminary Design and Cost Estimate on Schedule to be Complete by 2/2019
- ✓ EIV Preparation on Schedule to be Complete by 3/2019

Plans for Future Testing/Development/ Commercialization



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Acknowledgements

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HCERI: Shiwang Gao and Edward Wu
MTR: Tim Merkel and Ivy Huang
UTA: Gary Rochelle