Large Pilot Testing of Linde-BASF Advanced Post-Combustion CO_2 Capture Technology at a Coal-Fired Power Plant

Phase I

DOE/NETL Funding Award DE-FE0031581

Presenter: Kevin C OBrien, PhD

Director, Illinois Sustainable Technology Center

Director, Illinois State Water Survey

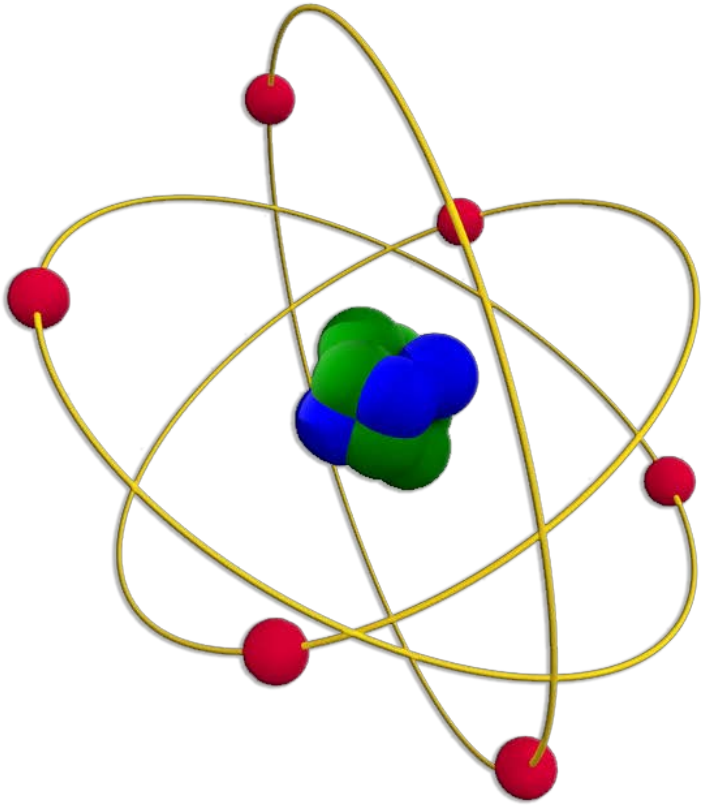
Prairie Research Institute

University of Illinois, Urbana-Champaign

2018 NETL CO_2 CAPTURE TECHNOLOGY PROJECT REVIEW MEETING AUGUST 13-17, 2018 PITTSBURGH, PA

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.



Funding, Objectives, Tasks, Timelines

PROJECT OVERVIEW

Overall Project **Objectives**

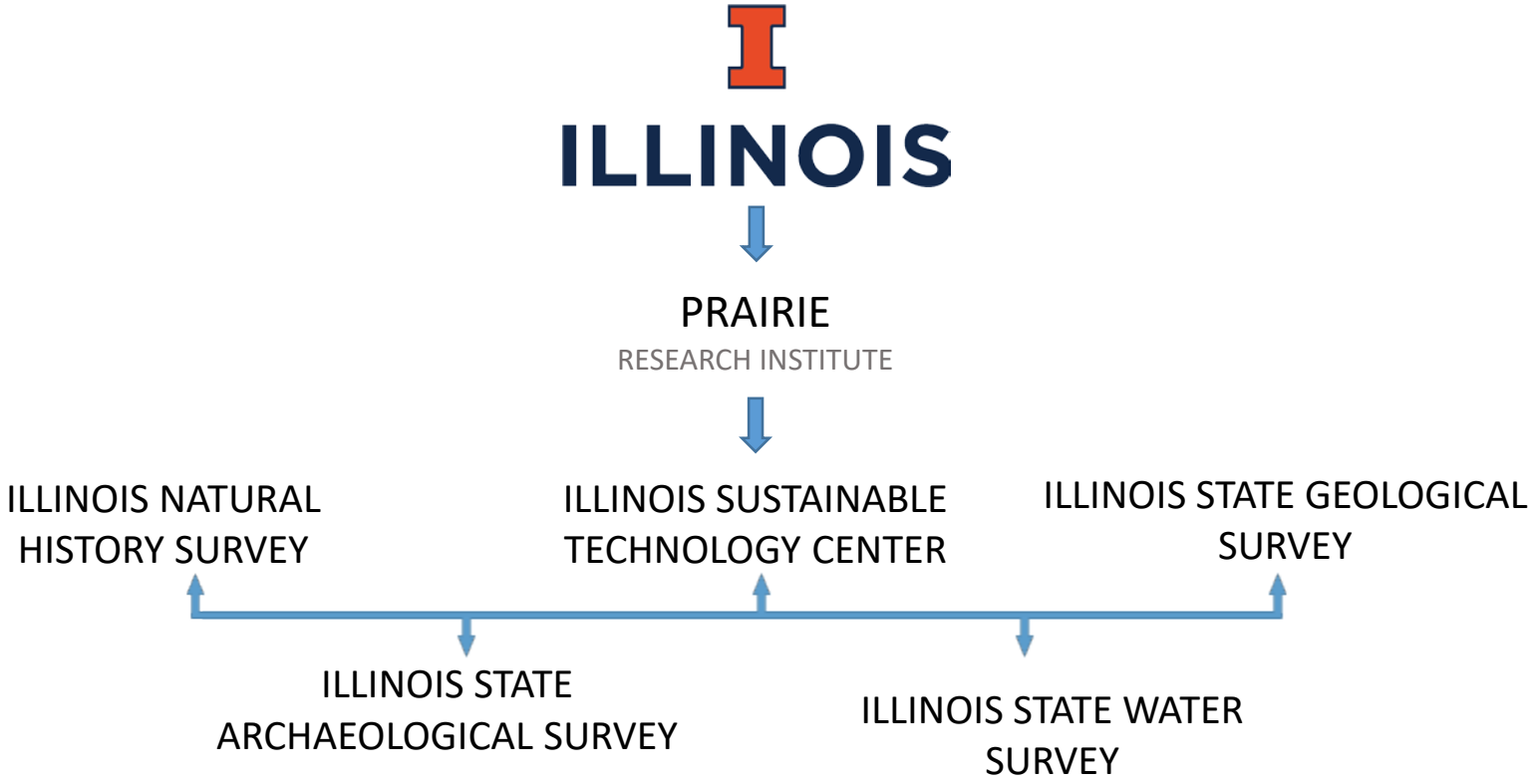
- Demonstrate a cost-effective technology to remove >90 percent of CO_2 at >99 percent purity scaled up to 10 MWe at an existing coal-fired power plant.
- Demonstrate the feasibility of transferring this scaled-up technology to other existing coal-fired power plants.
- Advance the Technology Readiness Level (TRL) of carbon-capture systems towards commercialization encompassing six critical carbon capture plant subsystems.
- Beneficially influence energy cost and grid reliability regardless of fuel used or power plant age.

Phase I **Objectives**

- Establish feasibility of installing a 10 MWe capture facility at one of two potential host sites
- Select a host site
- Complete Environmental Information Volume (EIV) for site
- Obtain commitments from site and team members for Phase II (including NEPA and FEED contractors)
- Update preliminary cost and schedule estimates for Phase II and Phase III
- Secure cost share for Phase II and plan for securing cost share for Phase III

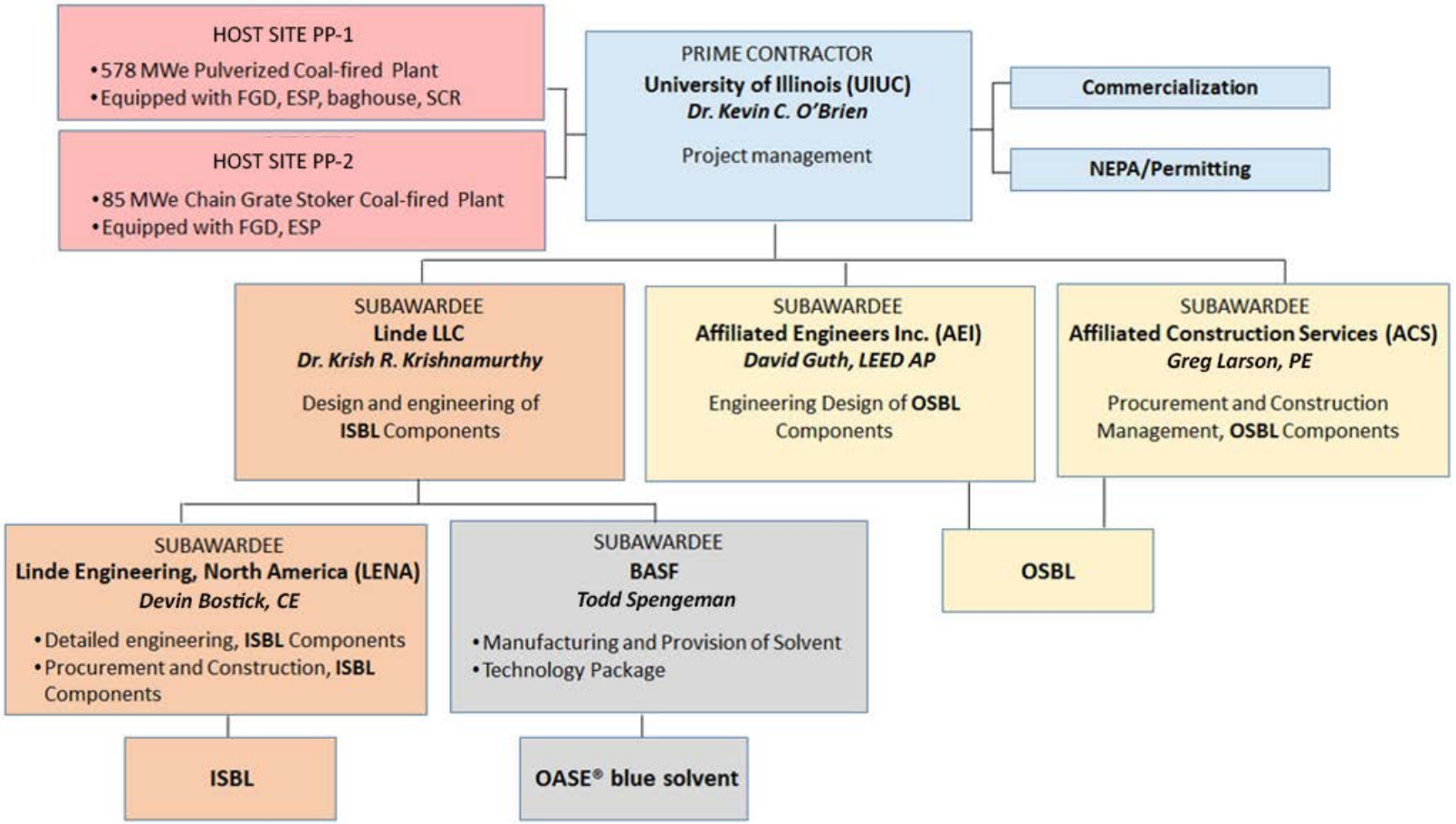
Prairie Research Institute (PRI) at the University of Illinois

Applied scientific research impacts the environment and economy,



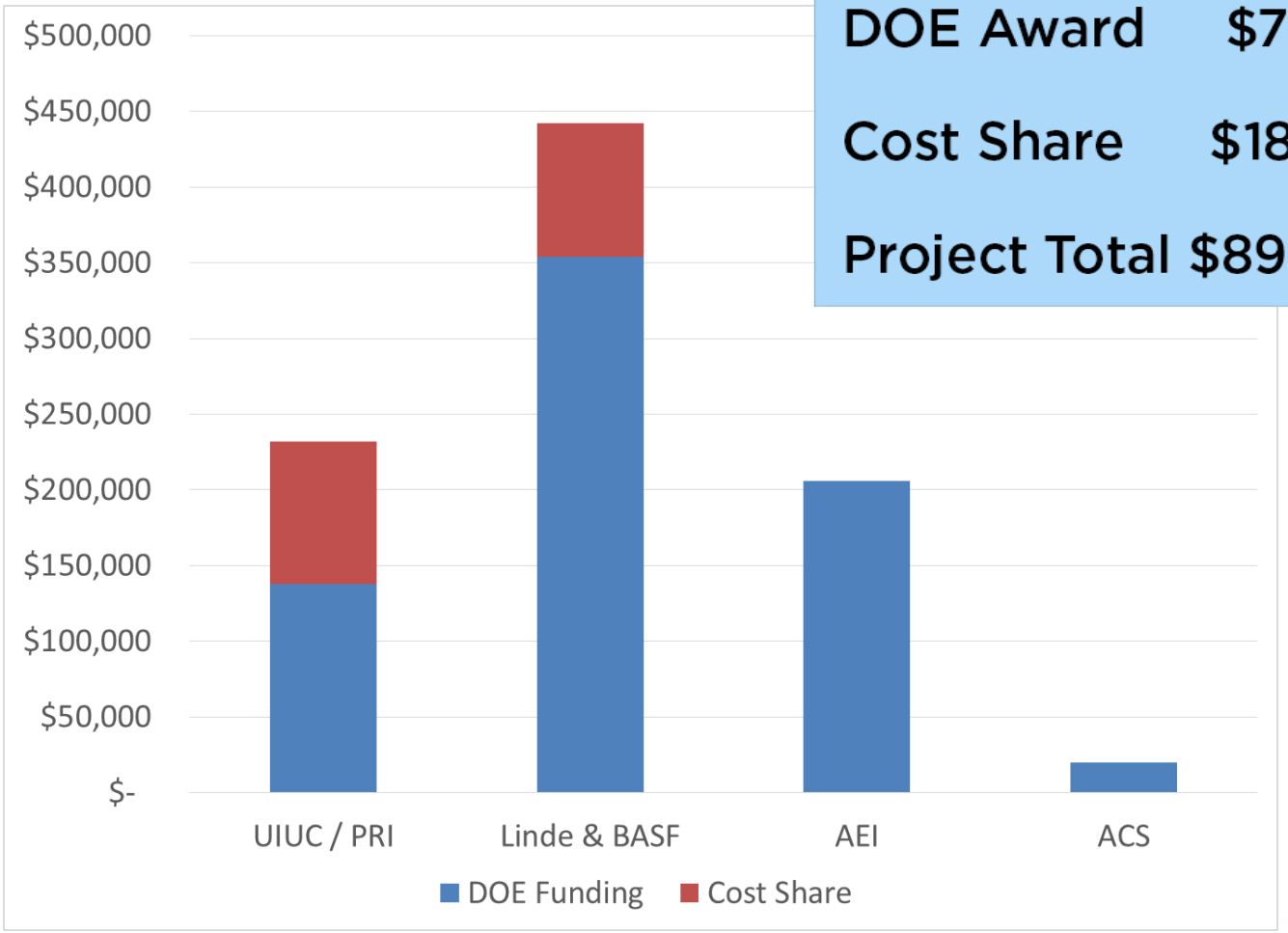
Phase I **Team**

Well-defined roles based on relevant capabilities



Phase I **Budget**

Reflects Learning from Previous Project



DOE Award	$717,125
Cost Share	$182,619
Project Total	$899,744

Phase I **Milestone Log**

Project on track

Budget Period	ID	Task Number	Description	Planned Completion Date	Actual Completion Date	Verification Method
1	A	1	Updated Project Management Plan	5/1/2018	4/20/2018	Project Management Plan file
1	B	1	Kickoff Meeting	5/31/2018	5/10/2018	Presentation file
1	C	2	Design and Engineering Site Analysis Complete	12/31/2018		Quarterly RPPR file
1	D	3	NEPA Contractor Selection	12/31/2018		Quarterly RPPR file
1	E	4	Host Site Selection and Commitment	1/31/2019		Quarterly RPPR file
1	F	5	Phase 1 Topical Report Completed	3/31/2019		Topical Report File
1	QR	1	Quarterly RPPR report	Each quarter		RPPR files

Niederaussen, DE

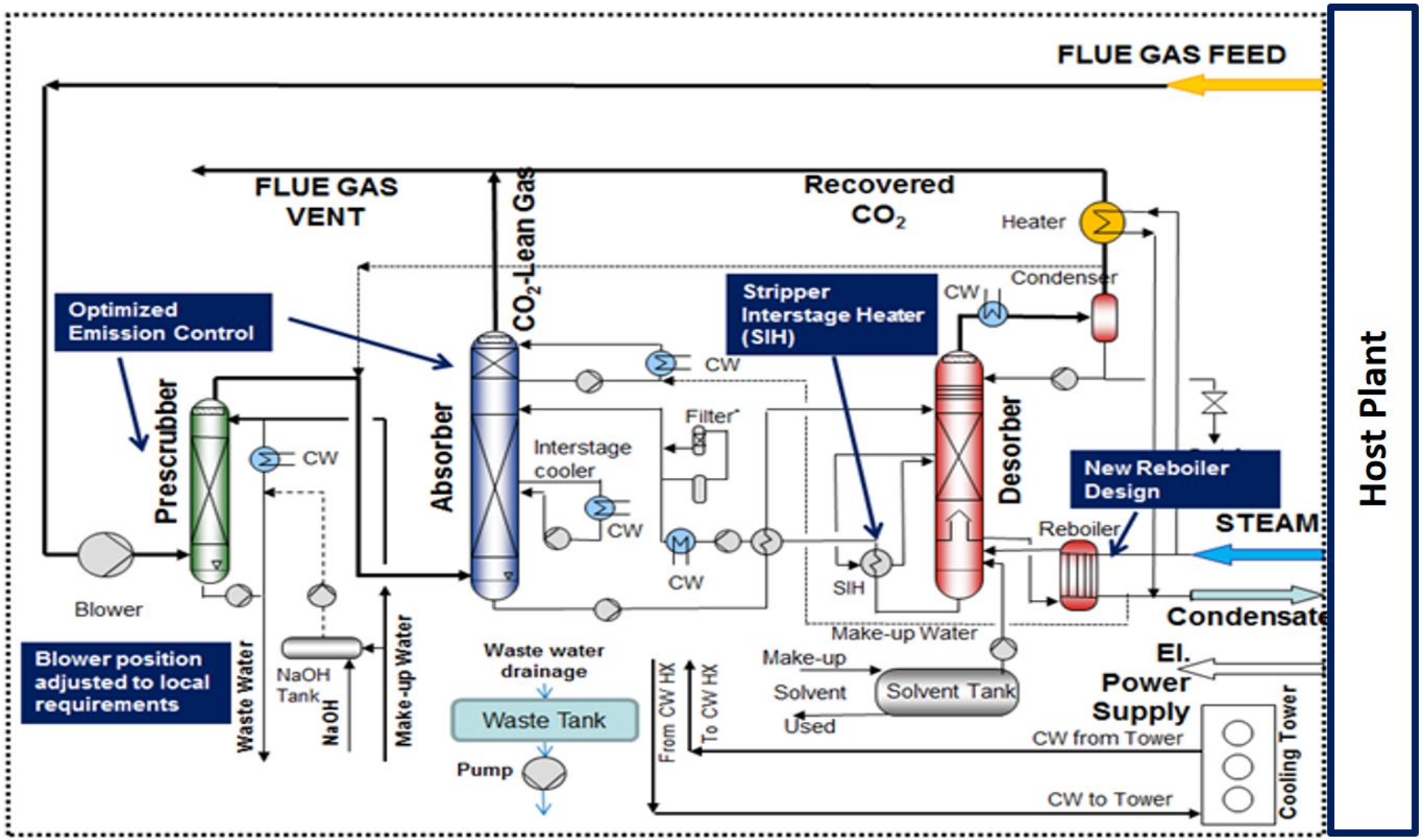
Wilsonville, AL

Champaign, IL

Background Overview of

TECHNOLOGY DEVELOPMENT

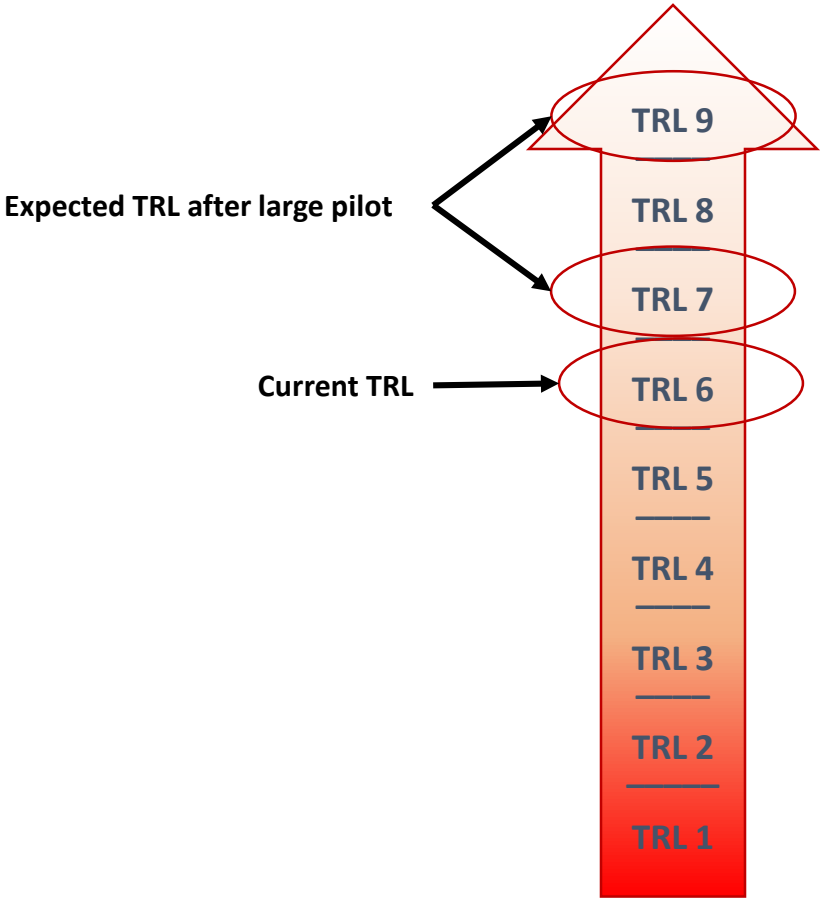
Overview of Large Pilot Plant Capture System



Technology Gap Analysis

TRL improvements that would result from large scale pilot

CO_2 Capture Plant Subsystems
Absorber and Stripper Columns[1]
Heat exchangers and reboiler
Stripper heat integration and recovery
Materials of construction
Emission control
Solvent Management



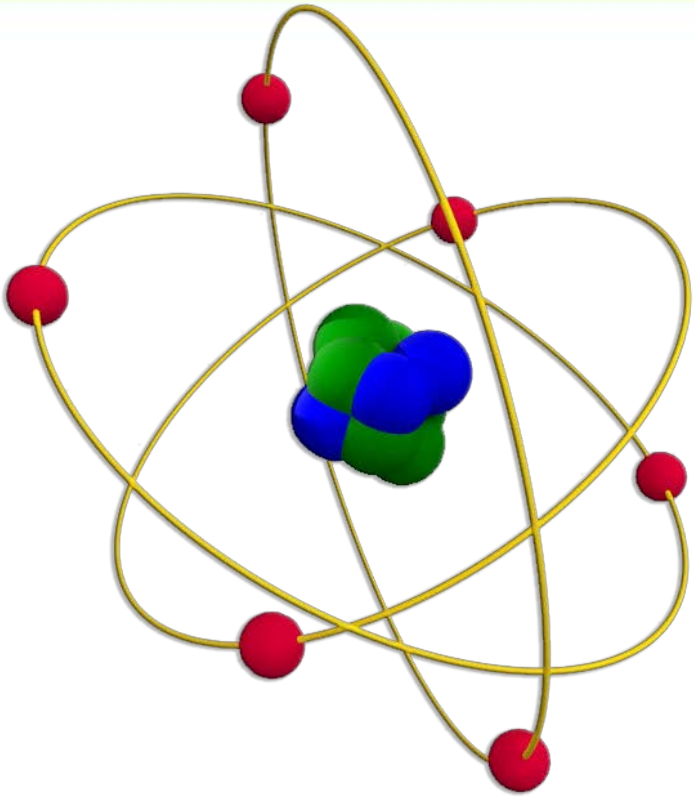
1. Columns expected to achieve TRL 9 based on Linde related experience in building up to ~ 12 m diameter columns for other commercial applications.

Expected Performance/Cost Summary

Based on 1.5 Mwe pilot test and Aspen Plus simulation results

Parameter	NETL Case 11	NETL Case 12	Linde Case LB1	Linde Case SIH
Scenario	No Capture	CO_2 Capture with MEA	CO_2 Capture with OASE® blue	CO_2 Capture with OASE® blue and SIH
Net power output (MWe)	550	550	550	550
Gross power output (MWe)	580.3	662.8	638.9	637.6
Coal flow rate (tonne/hr)	186	257	236	232
Net HHV plant efficiency (%)	39.3%	28.4%	30.9%	31.4%
Total overnight cost ($2011)	1,348	2,415	1,994	1,959
Cost of captured CO_2 with TS&M ($/MT)	N/A	67	52	50
Cost of captured CO_2 without TS&M ($/MT)	N/A	57	42	40
COE (mills/kWh) with TS&M cost included	81.0	147.3	128.5	126.5

LB1 - Linde-BASF PCC plant incorporating BASF's OASE® blue aqueous amine-based solvent
SIH - New Linde-BASF PCC plant incorporating the same BASF OASE® blue solvent featuring an advanced stripper inter-stage heater design



Project Success Criteria

INTEGRATION WITH HOST SITE

Selecting the Host Site

	Site Selection Criteria
Technical	Flue gas availability
	Flue gas CO_2 concentration
	Aerosol concentration in flue gas
	Steam and utility availability for ISBL
	Design costs for OSBL
	Available plot size for ISBL
	Use of domestic coal
	Existing abatement equipment (FGD, ESP, SCR, etc.)
	Logistics of transportation and lifting
Regulatory and Environmental	Permitting requirements
	Permitting timelines
	Supports NEPA
	Safety culture
Financial and Business Agreements	Cost share commitment
	Contractual terms and conditions
	Site interest
	Sign-off requirements
	Potential for capture system to permanently remain
	Interest in serving as future training site
	Personnel support and responsiveness

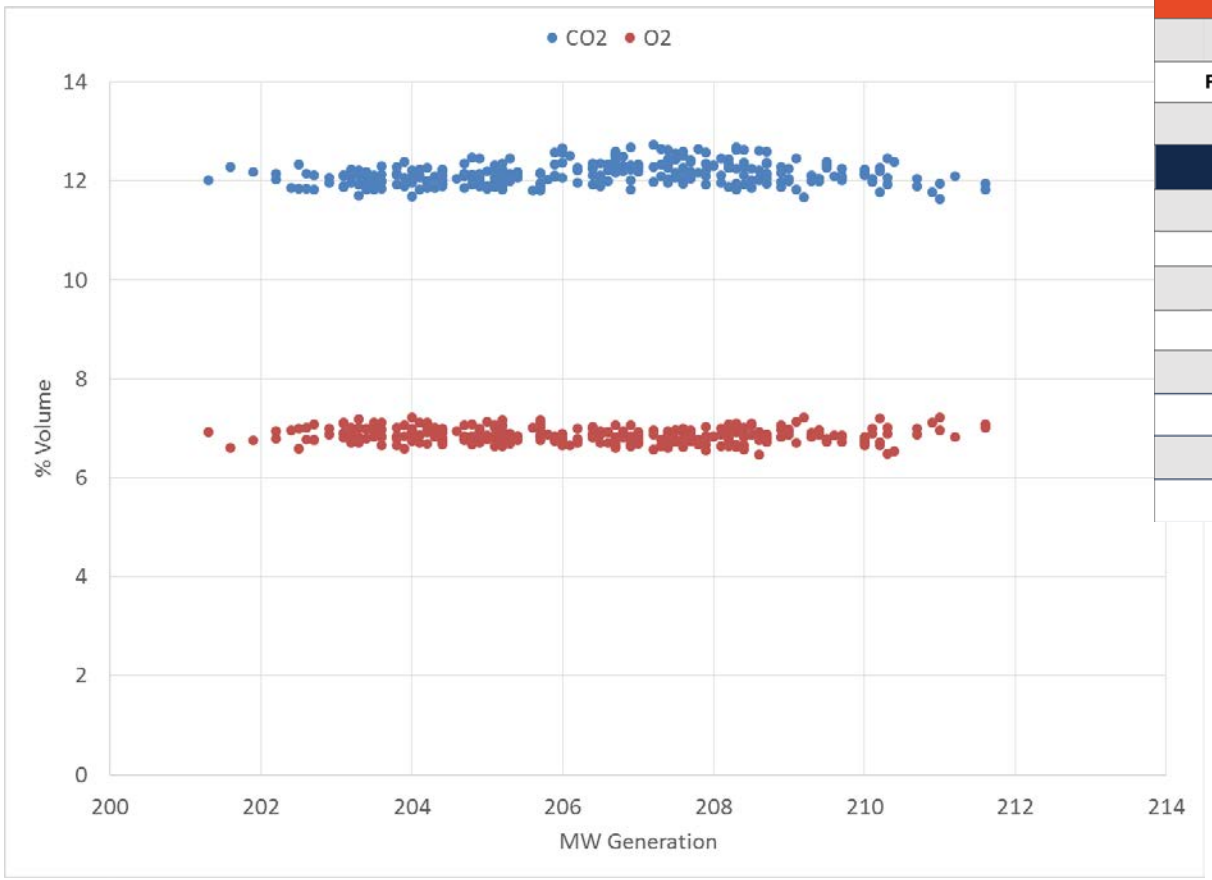
Host Site PP-1

Water and power supplier

OSBL Challenge at PP-1

Stack Gas Measurements at PP-1

Values compare well to traditional PC plant

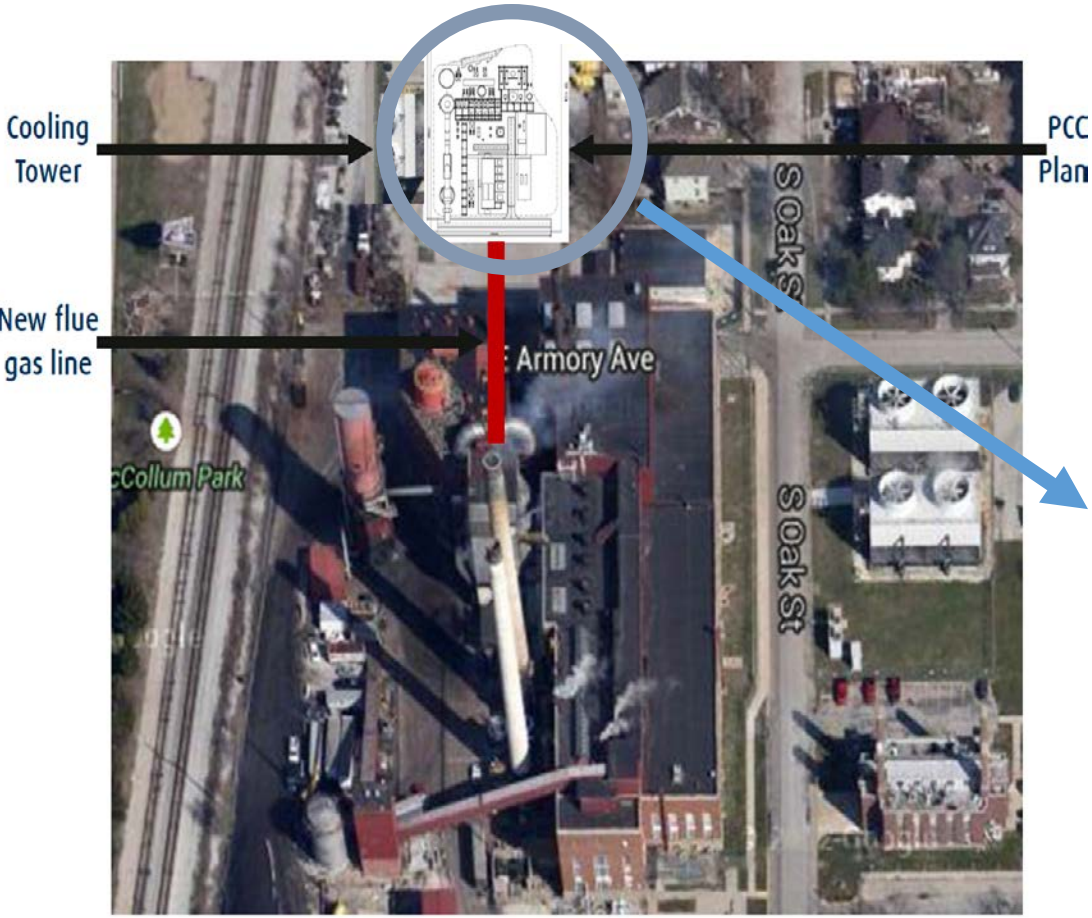


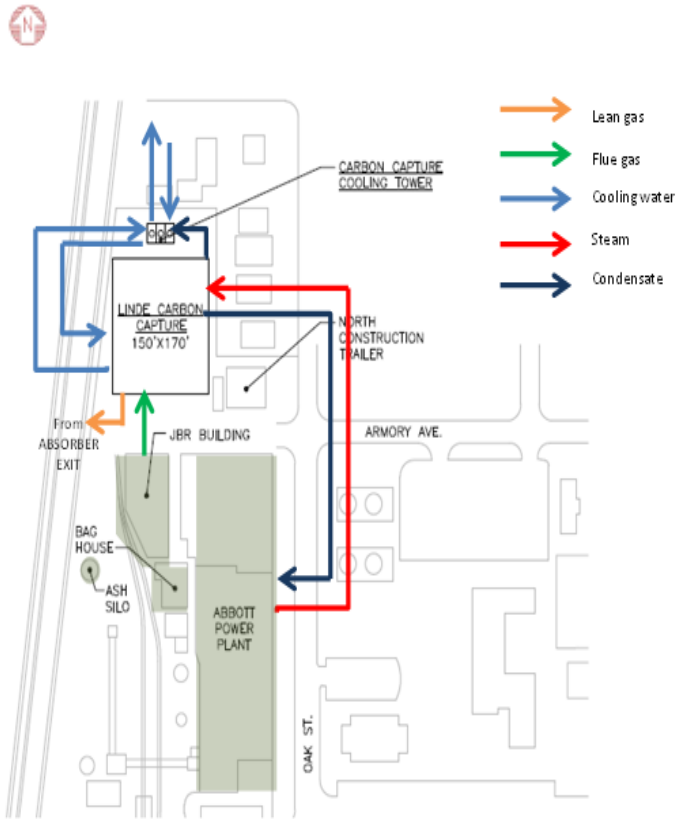
Item	Unit	Value
Temperature	°F	200
Pressure (gauge)	inch-Hg	0.2
Flow rate	acfm	675.985
Gas compsition		
Moisture	vol %	16.3
CO_2	vol % (dry)	12.8
O_2	vol % (dry)	6.4
SO_2	ppmv (dry)	31.3
NO_x	ppmv (dry)	23.0
HCL	ppbv (dry)	122
Hg	lb/hr	0.000336
Particulate	lb/hr	2.587

Host Site PP-2

- Three coal-based boilers; four natural gas
- **Separate treatment system for each fuel**
- Testing will run two coal boilers (IL high-sulfur coal)
- Electrostatic precipitators and a wet Flue Gas Desulfurizer (FGD) in place
- **Tradition of evaluating and showcasing new emission technologies**

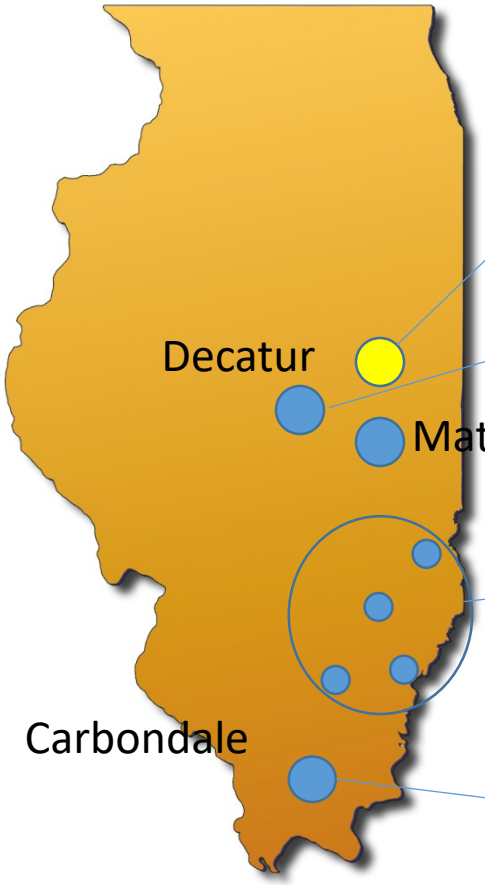
PP-2 Carbon Capture Plant Site Evaluated





Regional & Global Test Bed for CCUS

Concentration of natural resources and intellectual capital



- Capture of CO_2 : PP-1 or PP-2

ADM MGSC Richland Community College

- Storage of CO_2 : ADM Project

MATTOON
Mattoon, Illinois: *Working Together to Build the Future*

- Utilization of CO_2 : Enhanced Oil Recovery (EOR)

Illinois Eastern Community Colleges

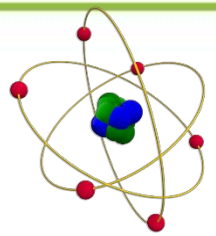
- Operator Training

Southern Illinois University Carbondale

- Coal combustion

ILLINOIS Prairie Research Institute · Linde · BASF · National Energy Technology Laboratory · U.S. Department of Energy · AEI Affiliated Engineers · ACS

Acknowledgements



Name	Organization
Andrew Jones	National Energy Technology Laboratory / US Department of Energy
Yongqi Lu, Vinod Patel, Randy Locke, Tom Durbin, Jim Dexter	PRI / University of Illinois
Krish Krishnamurthy, Devin Bostock	Linde
Todd Spengeman	BASF
David Guth	Affiliated Engineers Inc.
Greg Larson	Affiliated Construction Services, Inc.

This project is supported by the U.S. Department of Energy / National Energy Technology Laboratory (DOE/NETL) through Cooperative Agreement No. DE-FE0031581