



# Creating Markets for Captured Carbon:

## Retrofit of Abbott Power Plant and Future Utilization of Captured CO<sub>2</sub>

*Presenter : Kevin C OBrien, PhD*



*We've joined*

**The Paris Pledge for Action**

**WE** MUST CAN WILL 

**GHGT-13**

*Lausanne, Switzerland*

*15 November, 2016*

*Technical Session 1A – Amine Pilot Testing*



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# Prairie Research Institute: Illinois-focused Resource Research and Service

*Addressing societal challenges that impact Illinois and the global community*



**PRAIRIE**  
RESEARCH INSTITUTE



Driving the need for CO<sub>2</sub> Management

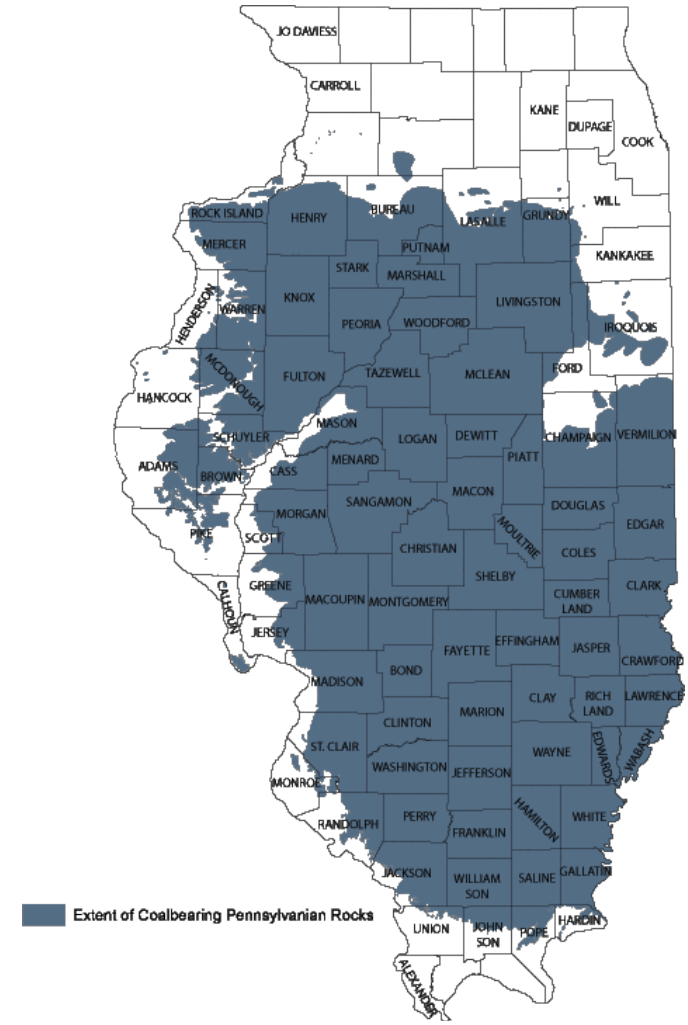
# MARKET TRENDS



# COAL: A SIGNIFICANT RESOURCE FOR ILLINOIS

*Underlies 95,830 m<sup>2</sup> (37,000 mi<sup>2</sup>) or 68% of Illinois*

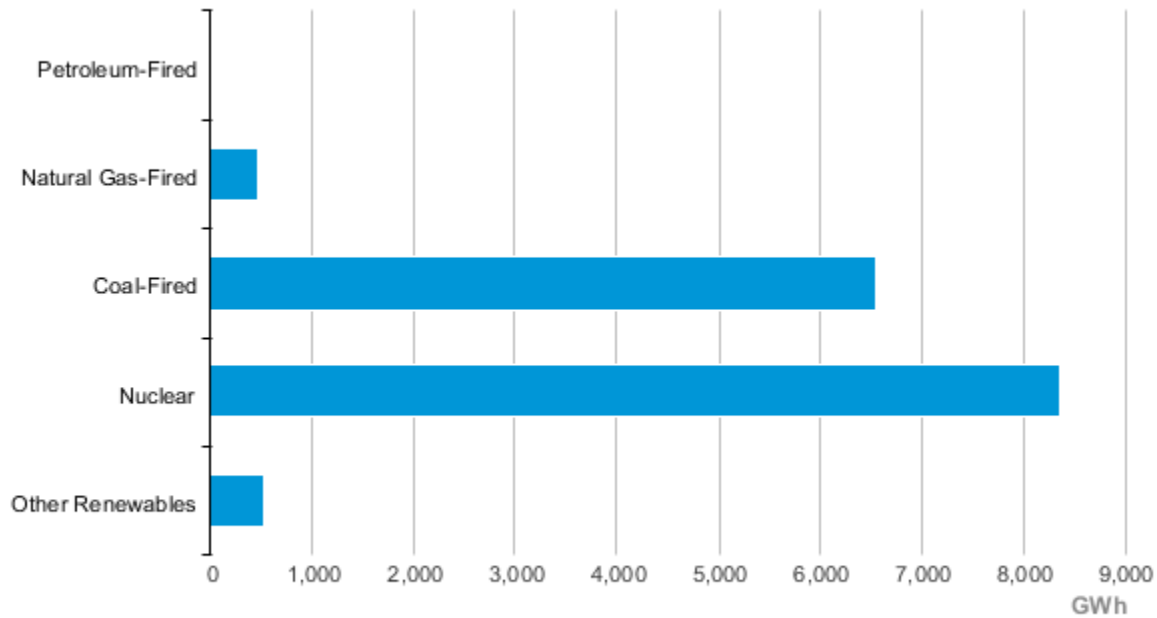
- More than 211 billion tons of identified resources are currently estimated to lie beneath the state
- Demonstrated reserve base is 112 billion tons, as defined in terms of minimum thickness and some geologic assurance of coal's presence
- Demonstrated coal reserve base is the second largest in the United States and, for bituminous coal, is the largest in the nation



# Illinois Energy Portfolio

*Nuclear and coal are key*

Illinois Net Electricity Generation by Source, Sep. 2014

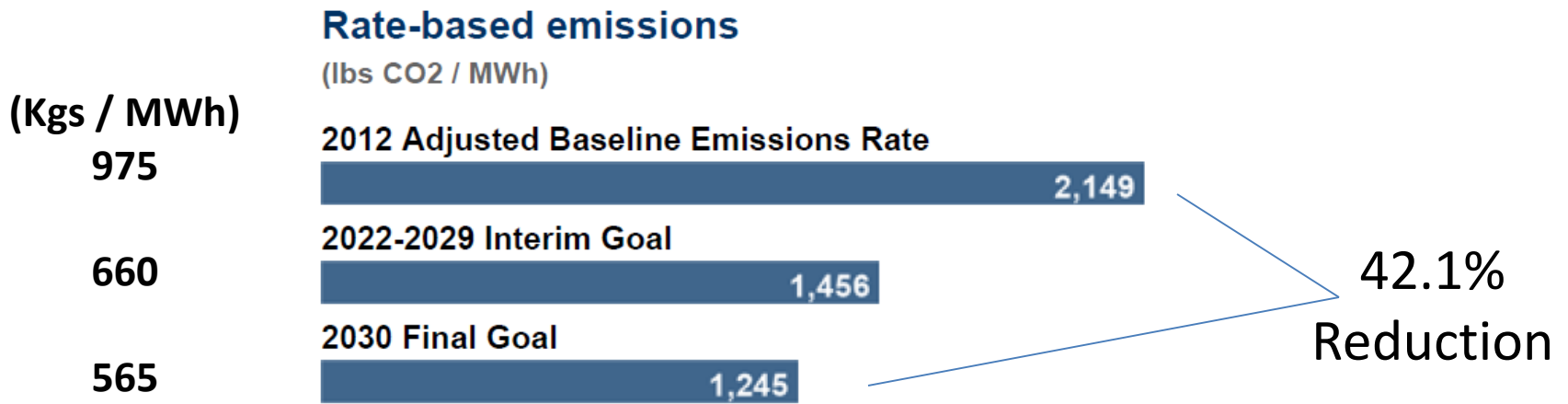


 Source: Energy Information Administration, Electric Power Monthly



# EPA Clean Power Plan Targets for Illinois

*Need to achieve by 2030*



The Illinois Solution

# BUILDING A MARKET FOR CAPTURED CO<sub>2</sub>





# Steps in Building a Market for Captured CO<sub>2</sub>

*Combination of partnerships, technologies, and interest in economic development*

- Find a Power Generator willing to host large scale pilot
  - Abbott Power Plant at University of Illinois
  - Traditionally evaluates new technologies and shares with other plants
- Assemble a “bondable” team with a proven capture technology (Phase I)
  - Linde/BASF provides proven technology
  - Linde/BASF; Affiliated Engineers Inc. experienced in large projects
- Obtain financing for project
  - Proposal to DOE for 15 MW large scale capture pilot
  - \$75 MM; \$58.5 MM DOE funds; \$16.5 MM cost share
- Construct and test a large scale pilot system at the power generator (Phase II)
- Large scale pilot evaluations of technologies for utilization of captured CO<sub>2</sub> (Phase III)
  - Forming Center for CO<sub>2</sub> utilization
  - Capitalizes on 300 Tons/day of CO<sub>2</sub> generated



# Host Site: Abbott Power Plant

*Ideal site for large scale pilot testing of coal and natural gas*

- Seven boilers total: three are coal based (Chain-grate stoker design) others natural gas
- **Coal side has completely separate treatment system from natural gas side**
- For testing will run two coal boilers
- Illinois high sulfur coal is burned
- Electrostatic precipitators and a wet Flue Gas Desulfurizer (FGD) in place
- **Tradition of evaluating new emission technologies**
- **Tradition of showcasing technologies to other power plants and education groups**



Major advantage that  
University owns and operates  
Host Site

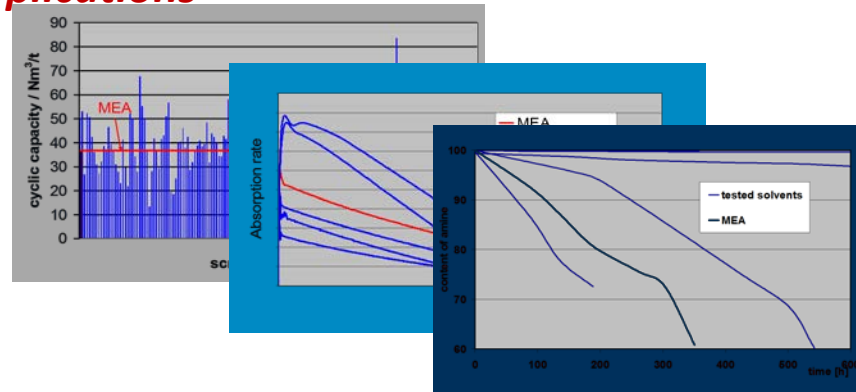
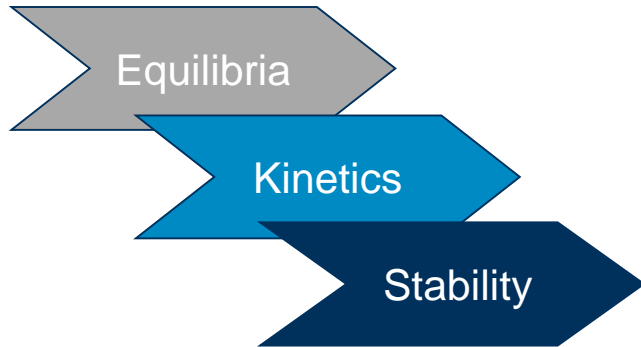
Successfully evaluated at the 1.5 MWe level at NCCC

# TECHNOLOGY DESCRIPTION



# BASF OASE<sup>®</sup> Blue Technology Development

*Adopted and Optimized for PCC Applications*



## Mini plant

- 2001, Ludwigshafen
- Solvent performance verification



## Pilot: 0.5MWe

- 2009, Niederaussem
- Process optimization, materials testing



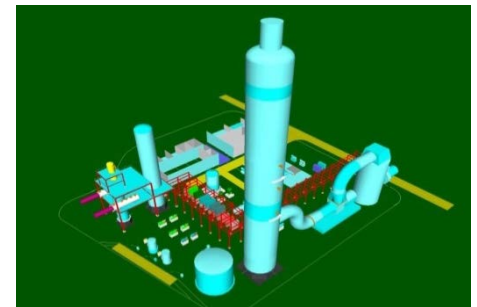
## Pilot: 1.5 MWe

- 2014, Wilsonville, AL
- Design improvements, emissions confirmation



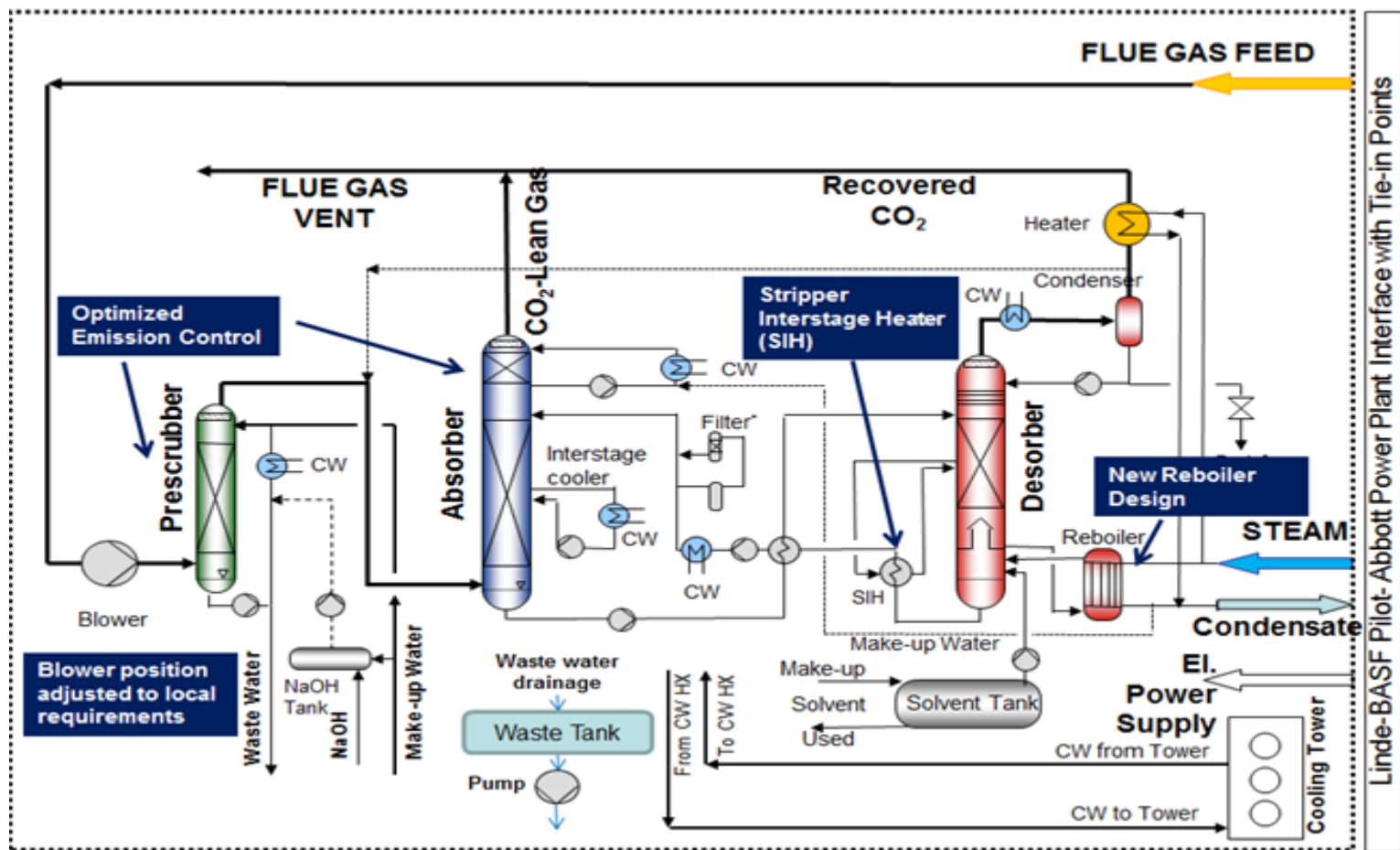
## Large Pilot: 15 MWe

- 2016/20, proposed
- PCC plant cost reduction
- Full value chain



# Overview of Capture System for Large Pilot Plant

## Technology features



Linde-BASF Pilot-Abbott Power Plant Interface with Tie-in Points

# Process Performance and Cost Summary 550 MW

*Based on 1.5 MWe Testing*

**Table 4. Process performance and cost summary for DOE/NETL cases compared to Linde-BASF technologies**

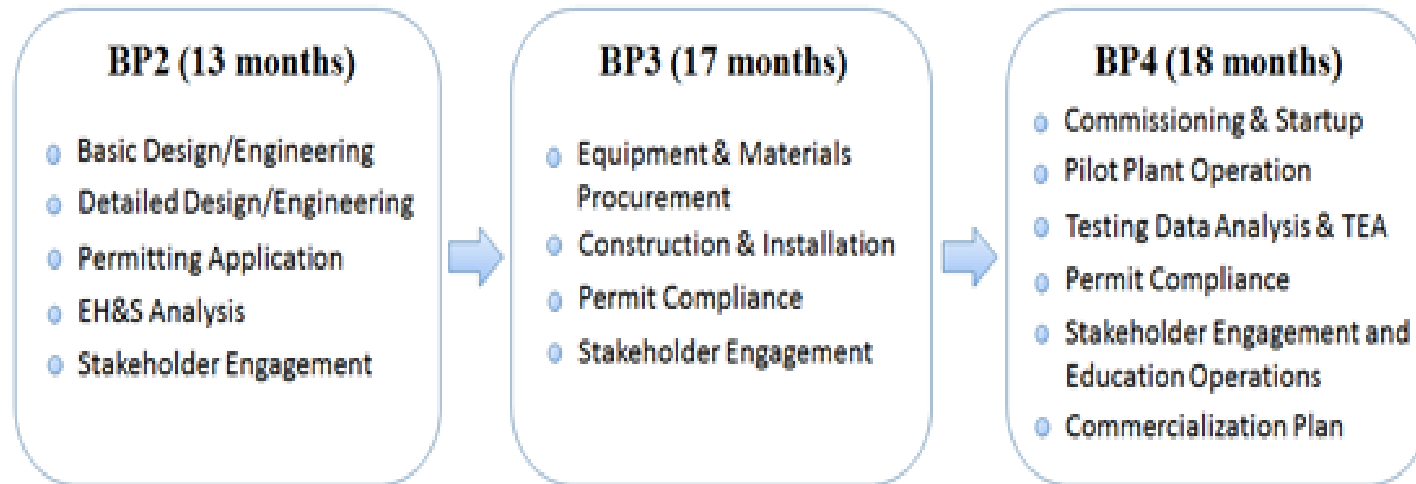
Parameter	NETL Case 11	NETL Case 12	Linde Case LB1	Linde Case SIH
Scenario	No capture	CO <sub>2</sub> Capture with MEA	CO <sub>2</sub> Capture with OASE <sup>®</sup> blue	CO <sub>2</sub> Capture with OASE <sup>®</sup> blue and SIH
Net power output (MWe)	550	550	550	550
Gross power output (MWe)	580.3	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 <sub>2</sub> with TS&M (\$/MT)	N/A	67	52	50
Cost of captured CO <sub>2</sub> 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<sup>®</sup> blue aqueous amine-based solvent**  
**SIH - New Linde-BASF PCC plant incorporating the same BASF OASE<sup>®</sup> blue solvent featuring an advanced stripper inter-stage heater design**



# Overview of Phase 2 Project Schedule

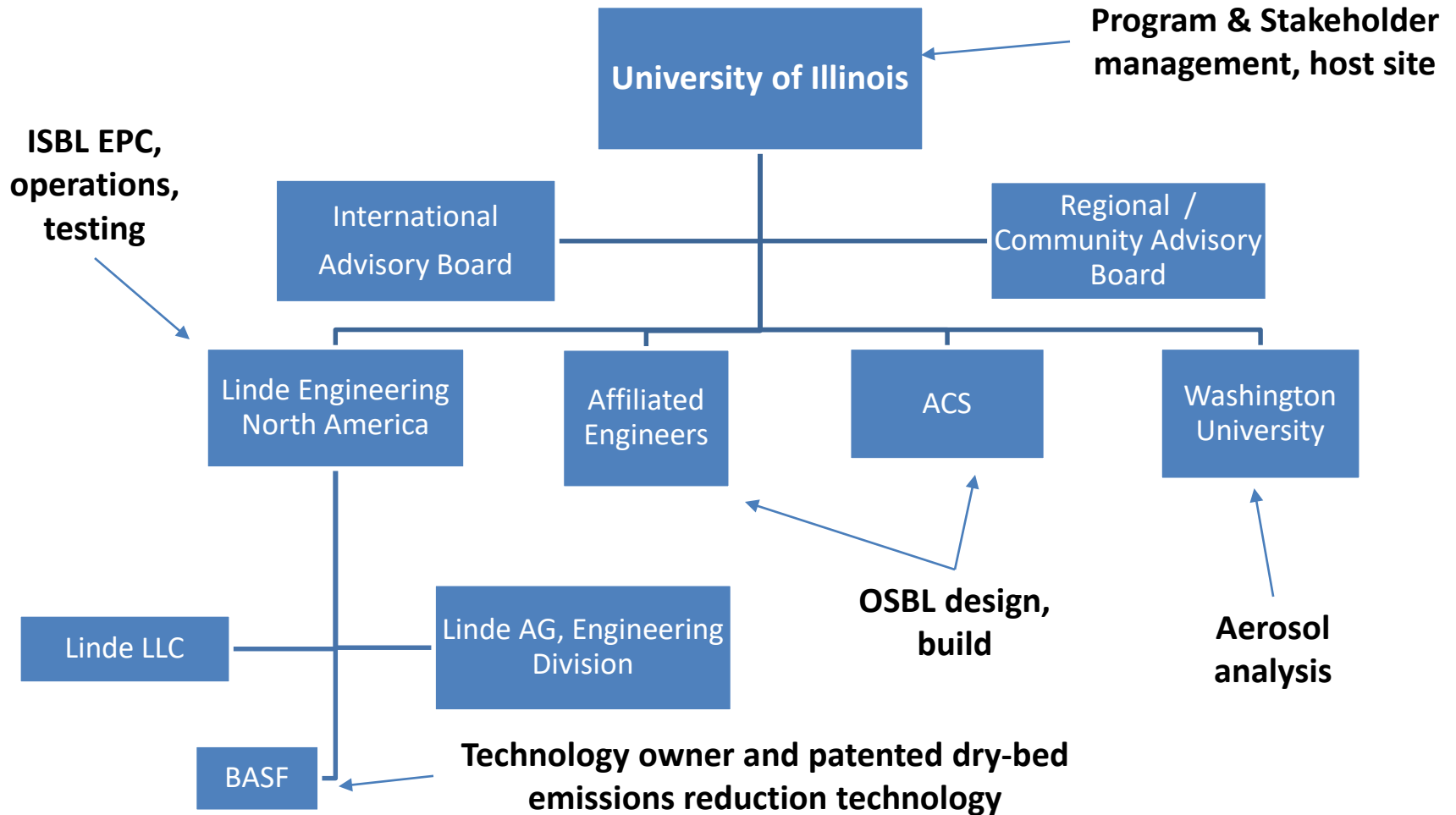
*More than just a design, build, operate project*



- ***Stakeholder Engagement helps educate , understand market needs, and propagate technology***
- ***Education: workforce development for existing and future operators and engineers***
- ***Demonstrating not only the technology but how to create jobs and drive regional economies***

# Phase 2: Project Organization Chart

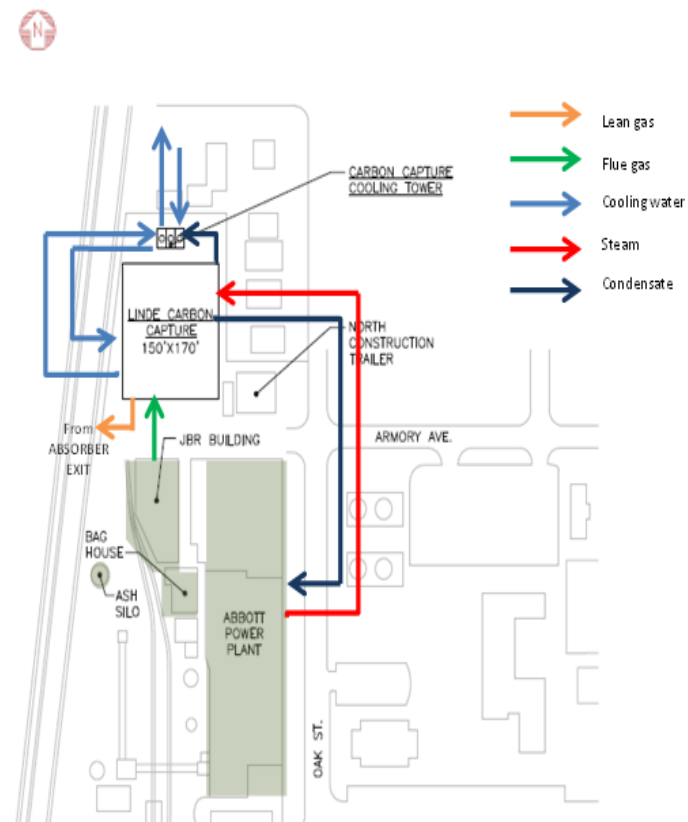
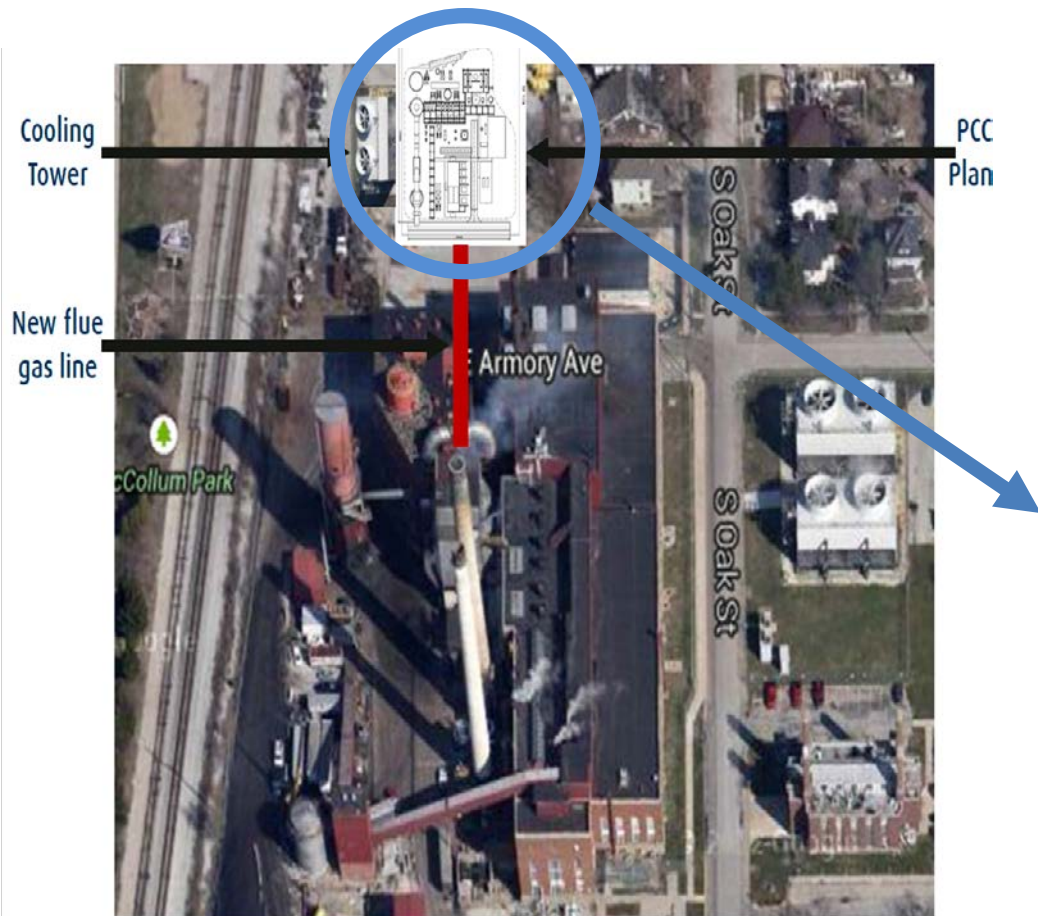
*Added expertise in aerosols, OSBL procurement / construction, and dry-bed emissions reduction*





# Site for Carbon Capture Plant Established and Evaluated

*Located close to Abbott Power Plant*

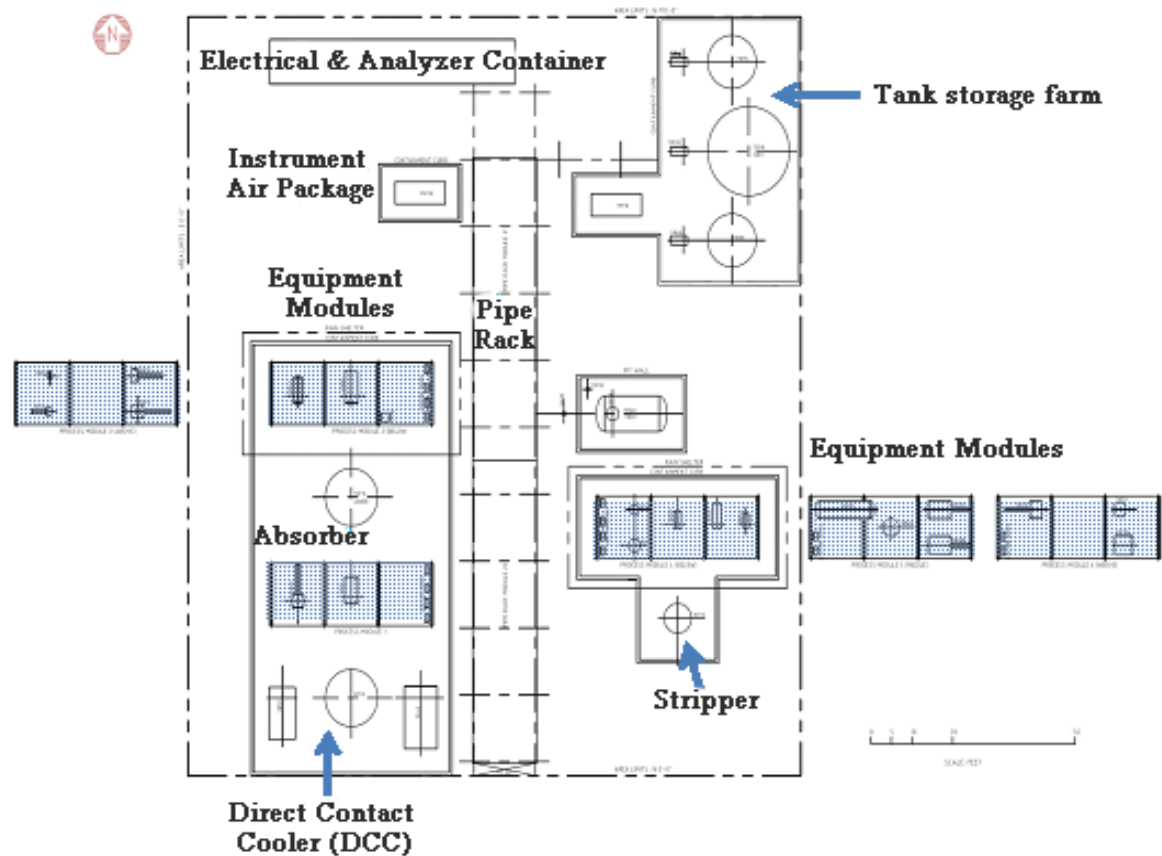


**Extract flue gas POST CEMS Unit**

# Plot Plan for Capture Plant

49 m x 46 m (160 ft. x 150 ft.) footprint

No modifications to existing plant combustion system (i.e. boilers) considered a major risk reduction by Abbott Power Plant



# Advisory Board for Capture Project and Center

*Key partnerships regionally and internationally*



# PROGRESS TOWARDS MARKET FORMATION



# Phase III: Center for CO<sub>2</sub> Utilization

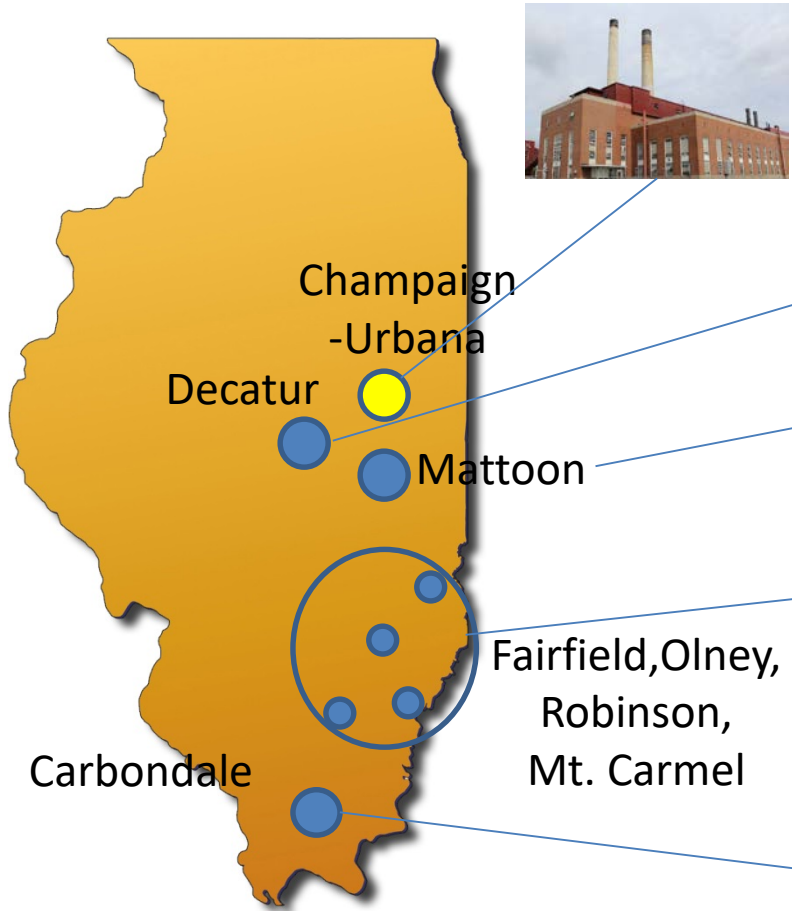
*Forming center to address market needs*

- Goal: Bring together university researchers and industry partners to examine large scale pilots to UTILIZE the captured CO<sub>2</sub>
- Looking for partners throughout the value chain, i.e. CO<sub>2</sub> users and CO<sub>2</sub> generators
- Looking for international partners willing to test large scale systems and share information
- Will include educational and workforce development components
- Developing research thrust areas now



# Regional & Global Test Bed for CCUS

*Concentration of natural resources and intellectual capital*



- Capture of CO<sub>2</sub> : Abbott Power Plant UIUC



- Storage of CO<sub>2</sub> : ADM Project



- Utilization of CO<sub>2</sub> : Enhanced Oil Recovery (EOR)



Illinois Eastern Community Colleges

- Operator Training



- Coal combustion



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