

Illinois Basin CCS Update: (Selected) Projects and Progress

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with

Team members at the

Illinois State Geological Survey (ISGS) and Illinois Sustainable Technology Center (ISTC),
Prairie Research Institute (PRI) – University of Illinois

2023 Midwest Regional Carbon Initiative (MRCI) Partners and Stakeholders Meeting, October 3-5, 2023

Slides adapted from material provided by Stephanie Brownstein, Jason Dietsch, and Kevin OBrien (ISTC), Veronica Hemrich (PRI), Roland Okwen, Carl Carman, Nathan Webb, Kendall Taft, Nate Grigsby, Curt Blakley, Mansour Khosravi, and Yongqi Lu (ISGS)

Illinois Basin CCS Overview

Geologic Storage:

- Illinois Basin CCS Activity
- Opportunities and Challenges
- CarbonSAFE and Other Studies

Industrial CO₂ Capture

Direct Air Capture

Regulatory Status (IL Examples)

- Wells & Pipelines
- Safety & Siting
- Federal/State/Local



Mt. Simon Sandstone core, ISGS

Geologic Storage: Illinois Basin CCS Activity

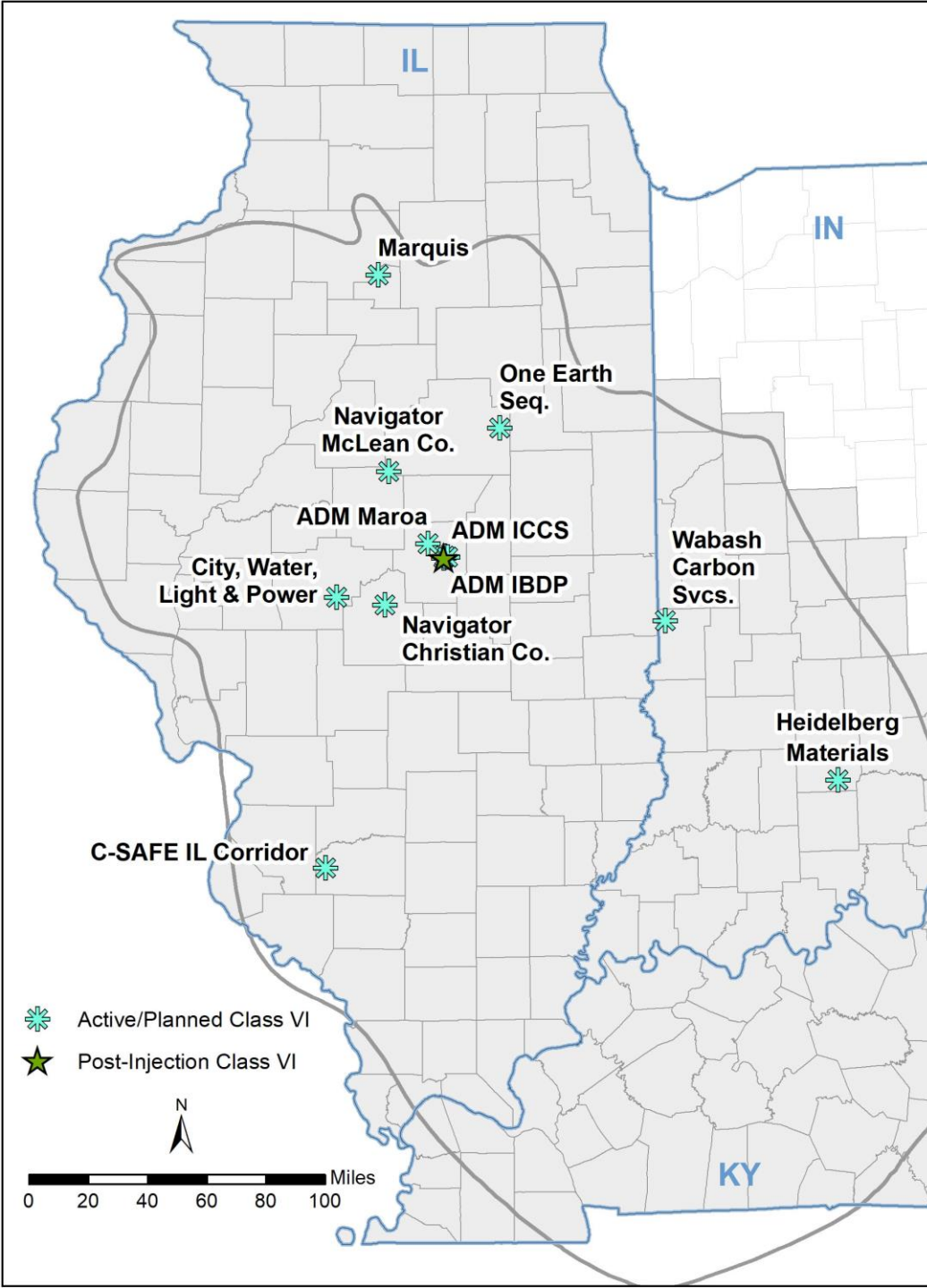
Public announced industry projects*

ILB: 18 USEPA Class VI permits submitted and admin. complete (Aug 2023):
(*EPA lists changing rapidly...)

- ADM – Decatur
Active injection well (~1 million tonnes/year)
Additional injection planned (Class VI permit in review)
- ADM – Maroa – 3 permits in technical review
- Navigator/Heartland Greenway
Christian Co. – 6 Class VI permits in review
McLean Co. – 2 Class VI permits in review
- One Earth Sequestration – 3 Class VI permits in review
- Wabash Carbon Services
2 draft Class VI permits (public comment period ended)
- Marquis – 1 Class VI permit in review

CarbonSAFE: Characterization + planned permits:

Mitchell CarbonSAFE (Heidelberg Materials)
CarbonSAFE Illinois Basin West (CWLP)
CarbonSAFE IL Storage Corridor (PSGC)



Geologic Storage: Opportunities and Challenges

Mt. Simon Sandstone: Strengths and challenges in Geology and Geography

(+) Proven reservoir in central IL; **target for many new projects**

(thick, porous, permeable, and deep)

(-) Porosity/permeability decrease in SE/deeper Basin:

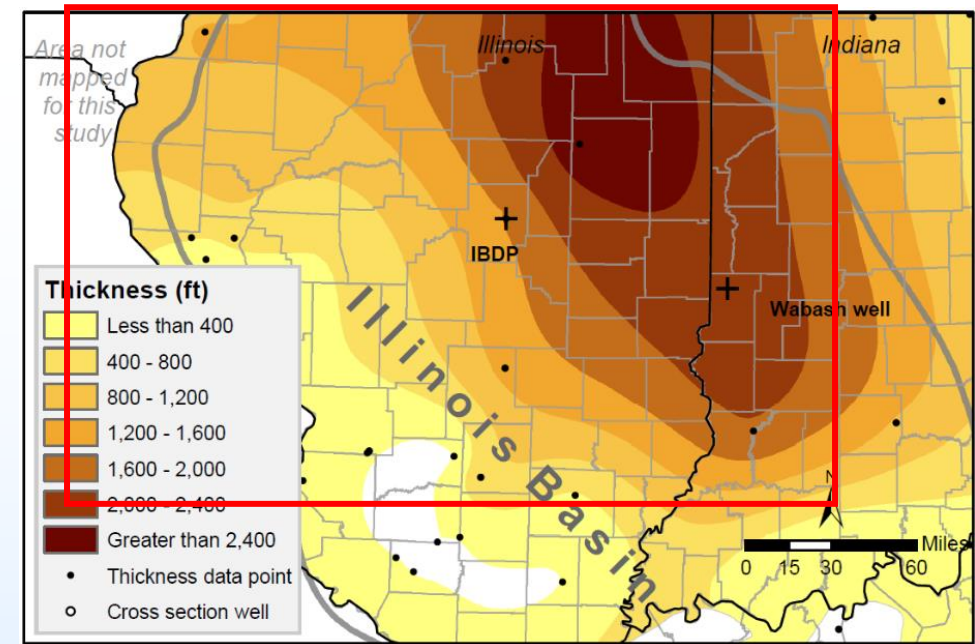
More quartz cementation, compaction

Finer grained, distal sediments from source (Wabash)

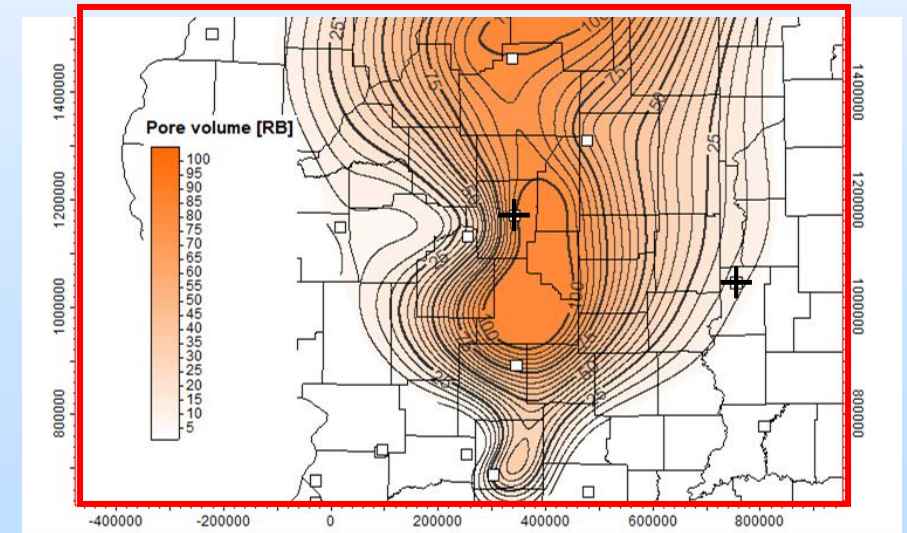
(-) Thins/absent to SW (ISC)

In these areas look to shallower formations

Evaluate existing regional geology, identify potential targets



Thickness of the Mt. Simon Sandstone

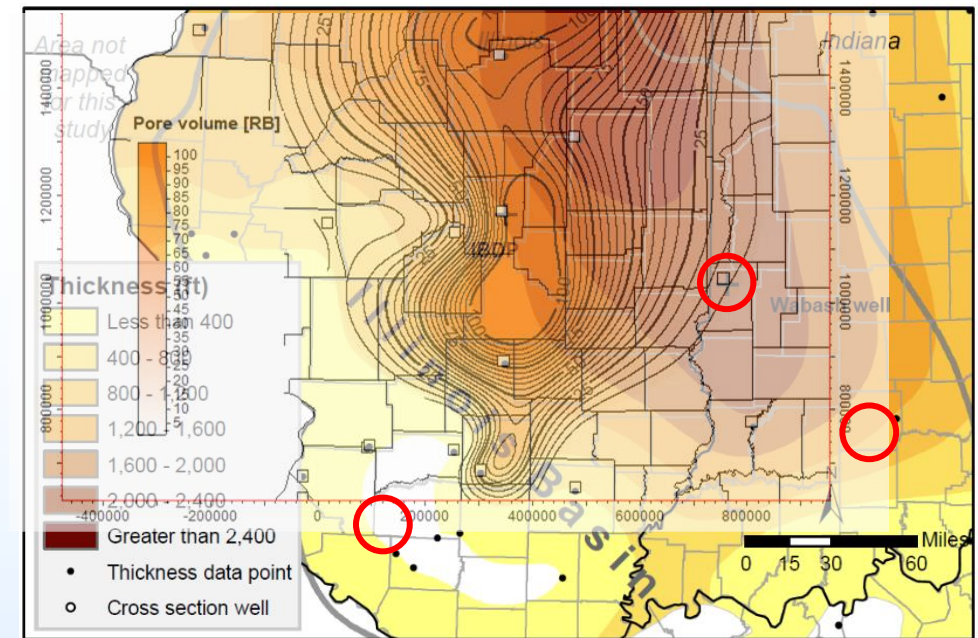


Pore Volume in the Lower Mt. Simon
 $PV = \text{Porosity} * \text{thickness}$

Geologic Storage: Opportunities and Challenges

Mt. Simon Sandstone: Strengths and challenges in Geology and Geography

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Potosi Dolomite: (Wabash, ISC)

- (+) Vuggy zones w/ very high porosity/permeability
- (-) Uncertain vuggy extent/interconnectedness

St Peter Sandstone/Everton Formation: (ISC)

Relatively thinner; depth/freshwater concerns around Basin margins

New Richmond Sandstone: (Mitchell)

Porous and permeable sandstone interbedded with dolomite; thick in SW Indiana
Saltwater disposal (Bailey well, 7mi S), CO₂ injection test (Blan well, KY/KGS)

SYSTEM	GROUP	FORMATION	Storage Elements	
Ordovician	Maquoketa	Brainard	Secondary Seal	St. Peter-Knox Storage Complex
		Ft. Atkinson		
		Scales		
	Galena	Kimmswick	Secondary Seal/Reservoir	
		Decorah		
	Plateville			
	Ansell	Joachim		
		St. Peter	Secondary Seal/Reservoir	
	Everton/Shakopee			
	New Richmond			
Knox	Oneota			
	Gunter			
	Cambrian	Eminence	Mt. Simon Storage Complex	
Potosi		Potential target		
Franconia				
Ironton-Galesville				
	Eau Claire	Primary Seal		
	Mt. Simon	Target reservoir		
	Precambrian			

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Geologic Storage: Opportunities

CarbonSAFE projects are helping us characterize these additional reservoirs beyond the Mt.Simon

Additional/related work:

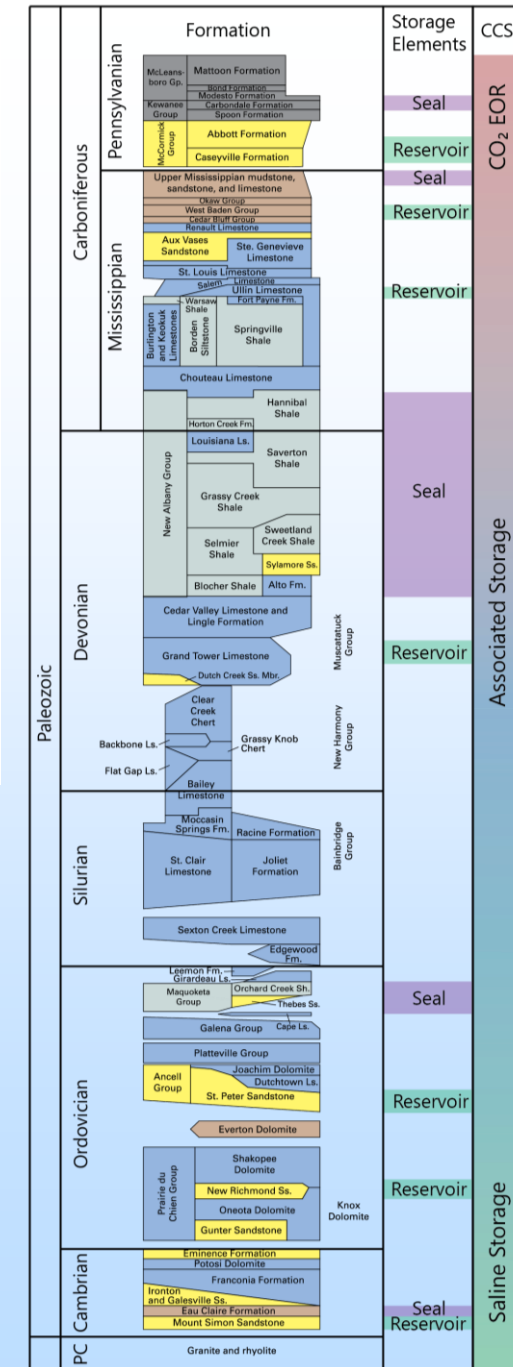
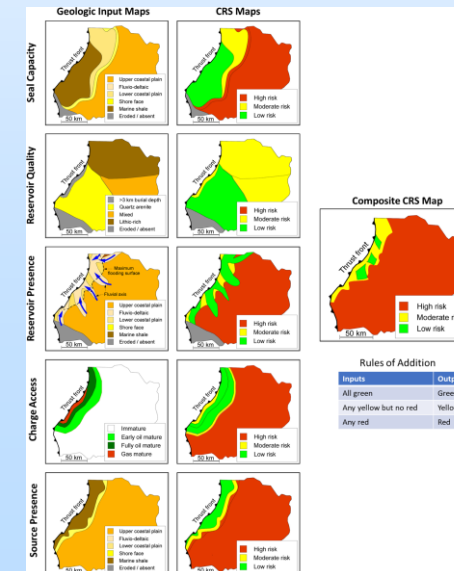
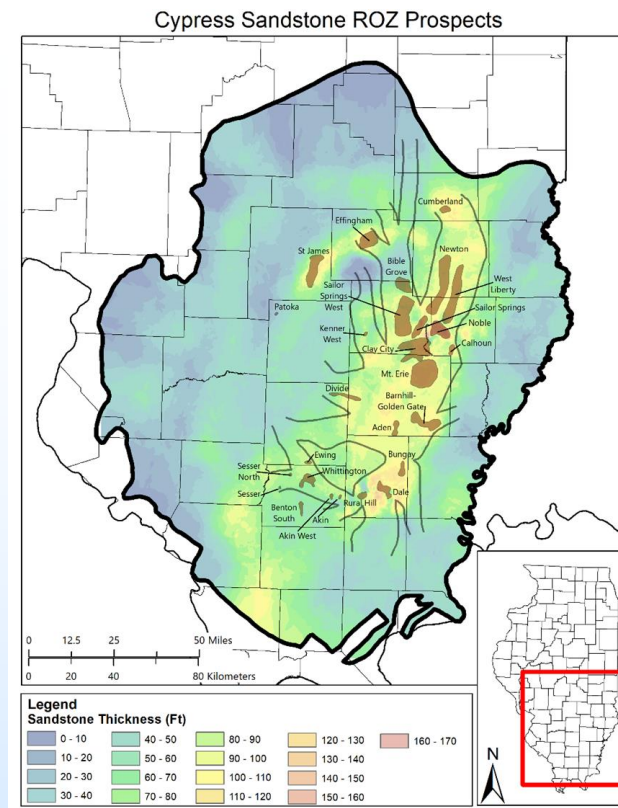
Residual Oil Zones (ROZ):

Oil recovery and associated carbon storage
Mapped ROZ fairways, potential prospects, stacked storage
Greenfield and brownfield field laboratory sites:
CO₂ injection, well testing, modeling

FOA2799 Projects:

- *A Play-Based Exploration of CO₂ Storage in the **Illinois** Basin (ISGS)*
- *Characterization of Subsurface Energy Opportunities to Accelerate Carbon Capture, Utilization, and Storage in **Indiana** (IGWS)*

Identify favorable areas that can support and inform commercial-scale storage facilities or carbon management hubs



Industrial CO₂ Capture (1)

ISGS/ISTC Development of New CO₂ Capture and Utilization Technologies (DOE):

CO₂ Mineralization and Utilization:

- Bench-scale tech development; carbonate + fertilizer with power plant Flue Gas Desulfurization (FGD) byproducts

Development of a Biphaseic Solvent-Based CO₂ Absorption Process for Post-Combustion CO₂ Capture:

- A new class of biphaseic solvents developed with required properties (kinetics, capacity, stability, corrosion etc.)
- A small pilot-scale (40 kWe) system built and tested at Abbott Power Plant; 90-95% CO₂ removal w/ ~40% less energy use
- Ongoing pilot project to test the technology at a Waste-to-Energy plant

Oxy-Combustion CO₂ Capture and Purification:

- Catalysts + reactors developed for the purification of O₂ residual and removal of NO_x/SO₂/Hg from Pressurized Oxy-Combustion (POC) flue gas
- Slipstream testing at 100 kW_{th} POC pilot facility demo: met CO₂ purity for EOR & geological storage @ lower capital cost + higher efficiency; industry scale-up ongoing

Honorable Mention: UK Center for Applied Energy Research (Lexington, Kentucky)

Lab/pilot-scale CO₂ capture research at [Kentucky project sites](#) in Lexington, Louisville, Ghent, KY

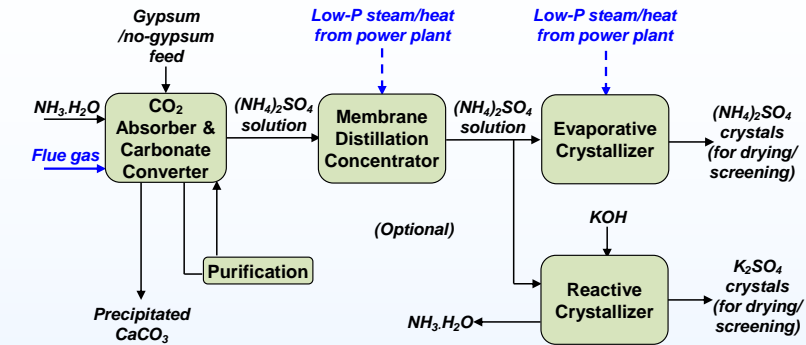


Diagram of ISGS' CO₂ Mineralization technology currently under development



Small pilot-scale (40 kWe) skid of ISGS' Biphaseic CO₂ Absorption Technology installed at the University of Illinois' Abbott Power Plant

Industrial CO₂ Capture (2)

Scale-Up of Industry Technology: FEED, Pilot Studies, Plans

Selected locations: Geological storage at ILB CarbonSAFE site hosts

Wabash Valley Resources:

Ammonia production from clean hydrogen
UOP fractionation process, 1.65 mil. tons CO₂ capture & storage
FEED completed (21st Century Power Plant),
Construction planned for 2024; Operation planned for 2026

One Earth Energy / One Earth Sequestration:

Ethanol production: 160 MMgal/yr; 458,000 tonnes/yr CO₂
Compression and dehydration FEED study completed (CarbonSAFE)
Company interested in storage hub (0.5 to 4.5 MTPA CO₂), advancing to the next stages
Looking at design of individual capture facility components; tie-in from other sources

Heidelberg Materials – Mitchell Cement Plant:

\$650M upgrade complete on June 15th; 2nd largest in North America
FECM FEED retrofit study (2023-2025): capture ~2.0 Mt CO₂/year
OCED CC Demonstration Project* awarded (in negotiation, follows CarbonSAFE characterization)
Transport/storage FEED, Community Benefits, Class VI Permit
Will leverage work at Edmonton plant in progress: CCS pilot/testing/implementation (operational late 2026)

*also Duke Energy Edwardsport IGCC integrated FEED



Wabash Valley Resources, West Terre Haute, IN



One Earth Energy, Gibson City, IL



**Heidelberg Materials
Mitchell, IN**

Industrial CO₂ Capture (2)

Scale-Up of Industry Technology: FEED, Pilot Studies, Plans

Selected locations: Geological storage at ILB CarbonSAFE site hosts

Prairie State Generating Company:

Coal fired power station (2012); 1600 MW (2 units)

FECM Full-scale capture FEED study for 8.125 MTPA CO₂ capture from 1 unit; Mitsubishi solvent-based
CarbonSAFE – Illinois Storage Corridor project assessing storage near site location



City, Water, Light & Power:

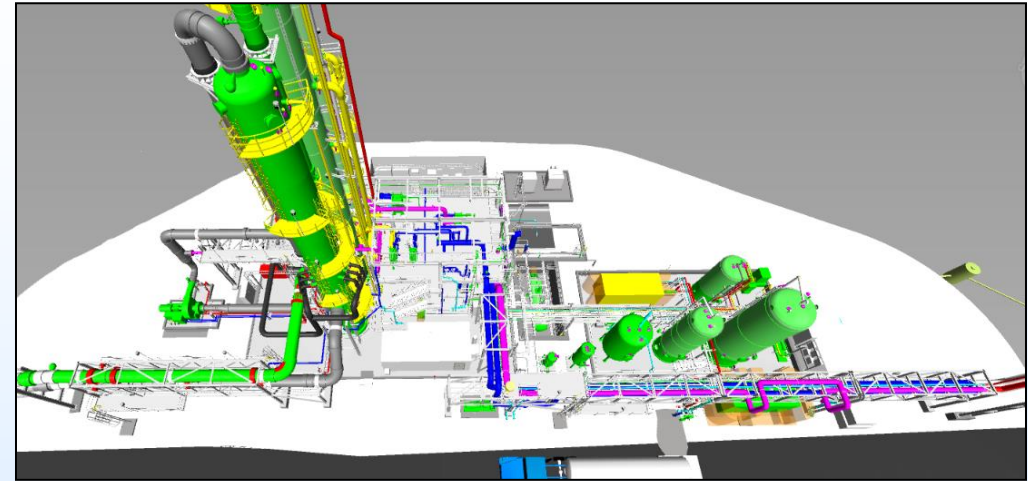
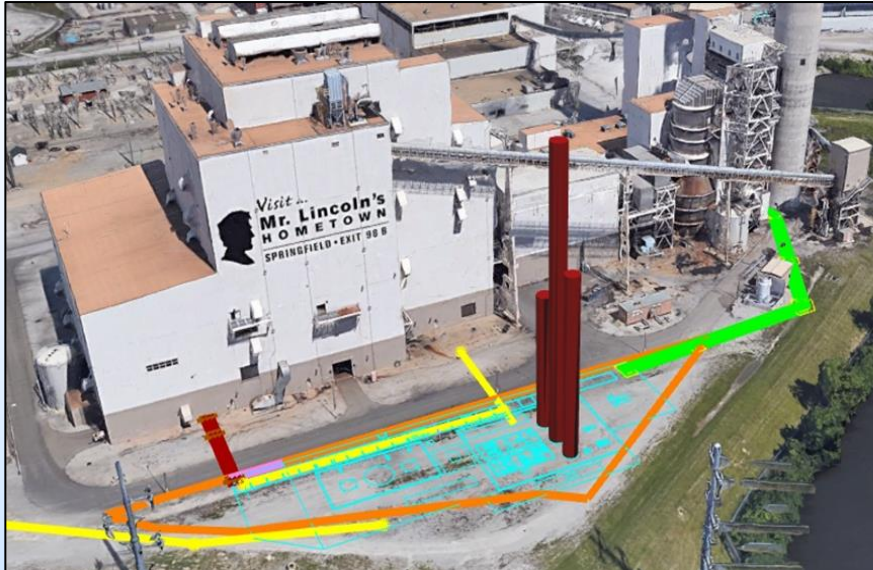
Dallman Unit #4 (2009): one of nation's cleanest coal-fired units;
history of company cooperation with research

City, Water, Light & Power
Springfield, IL



- 2 pilots (ISTC), construction underway:
 - 1) FECM **Large Pilot**: LINDE-BASF amine solvent; 5% of Dallman #4 emissions (10MW)
 - 2) NETL Algae Utilization Pilot: small slipstream from Dallman #4, CO₂ for algae -> biomass fuel/ poss. feed
- FEED studies, upcoming/negotiating:
 - 3) 21st Century Powerplant FEED Study: “if build new today”, innovative hybrid combined coal/gas/biomass with CO₂ capture & energy storage
 - 4) OCED Demo FEED for capture, transport, sequestration: 100% of Dallman #4 emissions (230 MW max gross)

CWLP Large Pilot – Plans and Construction Progress

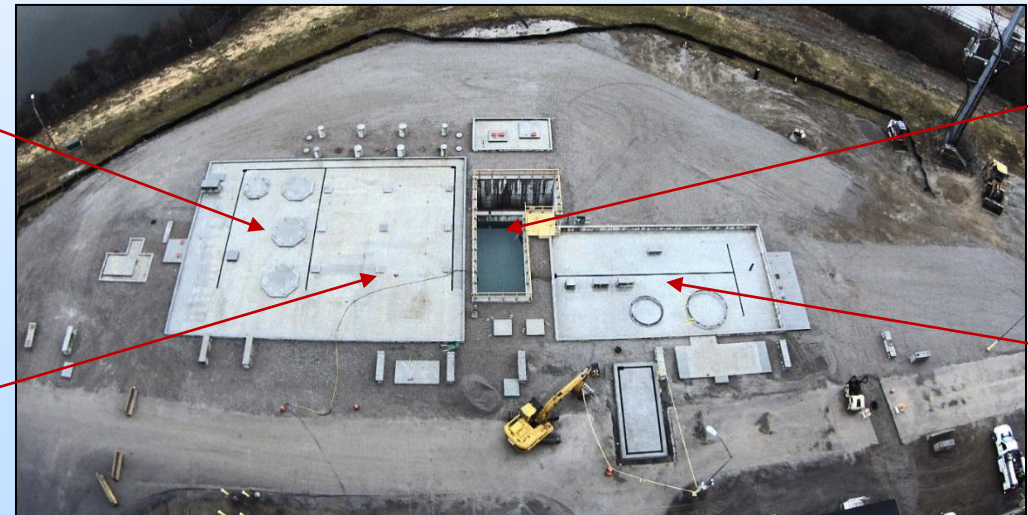


Columns

Modules

Pits

Tanks



Base construction for utilities, foundation, wastewater, etc.
May? 2023

Direct Air Capture (DAC)

Illinois Sustainable Technology Center (ISTC)

Direct Air Capture-Based Carbon Dioxide Removal with United States Low-Carbon Energy and Sinks (Initial Design – through 12/2023)

Utilize low-carbon energy sources to power commercial-scale DAC operations

Evaluate DAC in three test site climate types using Climeworks' technology:

Hot and very dry climate – in **southern California** with DAC system powered by geothermal energy; captured CO₂ will be stored in a saline aquifer.

Hot and humid climate – in **Louisiana** using solar energy; CO₂ stored in a saline aquifer.

Midcontinental climate – in **Wyoming** using wind power; CO₂ stored in a depleted natural gas reservoir.

Regional Direct Air Capture Hubs (announced [August 2023](#))

ISTC selected to lead feasibility studies for 3 Regional DAC Hubs:

Illinois Basin Regional DAC Hub – proven geological storage strata stretching under Illinois, Indiana and Kentucky.

Colorado (Pueblo) Regional DAC Hub – build upon previous geological studies in the Denver-Julesburg Basin.

Florida Regional DAC Hub – Tuscaloosa Group (thick, permeable saline aquifers 4,920 to 7,050 feet deep).

Direct Air Capture Coalition (ISTC at Univ. of IL joins DACC, [8/29/2023](#))

Nearly 100 global members to share best practices in DAC development and deployment, scale DAC technology, and educate key audiences on the critical importance of DAC deployment and carbon removal efforts on a global scale.



Climeworks' Orca DAC plant, Hellisheiði, Iceland.

IL Regulatory Status (Wells)

Safety and Siting: Mix of Federal, State, and Local Laws

Federal: No state primacy; US EPA UIC Program Class VI well permitting and monitoring regulations

State:

(Indiana Public Law 163 / HB 1209 (7/31/2022) – Provides for the mechanism for underground storage of carbon dioxide in Indiana: clarifies pore space consent (70%+), long term liability, annual fee; still requires US EPA permit)

- Illinois lawmakers continue to look at ways to address safety and siting issues:
Spring 2023, bills introduced to address safety and siting (and property) issues related to CO₂ capture, storage, and transportation.
Bills did not pass, they could be revived during the Fall Veto Sessions (October 24-26 + November 7-9, 2023) or be reintroduced in some form in the Spring 2024 Session.
- Illinois CCS report, required by Public Act 102-0341 (08/31/2021)
Prairie Research Institute (Univ. of IL) required to research and produce an objective report on:
potential for carbon capture, utilization, and storage as a climate mitigation technology,
including addressing “any risks to health, safety, the environment, and property uses or values”
(110 ILCS 305/120 (a)(11)) .

Carbon Capture, Utilization, and Storage in Illinois and *Carbon Capture, Utilization, and Storage in Illinois: Law and Policy Supplement* were submitted to the Governor and the Illinois General Assembly on Dec. 16, 2022, and were made publicly available on Jan. 9, 2023. <https://www.ideals.illinois.edu/items/125493>.

IL Regulatory Status (Wells)

Safety and Siting: Mix of Federal, State, and Local Laws

Local Level

September 2023, McLean County IL – Land Use and Development Committee:

Proposed zoning ordinance amendments: require energy companies drilling CO₂ sequestration wells to apply for a special-use zoning permit RE: setbacks, lighting, and mandate local emergency response plan (*and* funding)

Reported as Committee interest that no CO₂ well permits are allowed over Mahomet Aquifer ([WGLT](#), 09/05/2023)

State → Local Level

A Senate committee in Indiana voted down a passage of [Senate Bill 247](#), which would have required local government approval (county, or city/town) of CCS projects ([Benton Review](#). 09/23/2023).

Issue: Local input/needs vs. additional layers of approval necessary to proceed

IL Regulatory Status (CO₂ transportation via pipelines)

Safety and Siting: Mix of Federal and State Laws

Safety

Federal Pipeline and Hazardous Materials Safety Administration (PHMSA) safety regulations for CO₂ pipelines:

PHMSA is updating its pipeline safety standards to apply to CO₂ pipelines to include:

- Updated emergency preparedness and response requirements, and

- Updated mitigation planning related to land-movements and geohazards that pose risks to CO₂ pipeline integrity.

The PHMSA revisions for CO₂ pipelines are still pending but have an estimated [Federal Register publication date of January 26, 2024](#) (PHMSA).

IL Regulatory Status (CO₂ transportation via pipelines)

Safety and Siting: Mix of Federal and State Laws

No federal authority over CO₂ pipeline siting (excluding BLM for federal lands); responsibility falls on states to establish a regulatory framework for inter-and-intrastate CO₂ pipelines.

Siting (Illinois): The [Illinois Commerce Commission \(ICC\)](#) regulates intrastate siting of CO₂ pipelines under the [Illinois Carbon Dioxide Transportation and Sequestration Act](#) (220 ILCS 75/1 et seq.)

- In-state portions of CO₂ pipelines that have been “designed, constructed, and operated” to exclusively transport and sequester CO₂ (220 ILCS 75/10 and 220 ILCS 75/15)
- Certificate of Authority gives CO₂ pipeline owners/operators *a limited grant of authority* acquire easement in any property for the construction, maintenance, or operation of a CO₂ pipeline under [Illinois Eminent Domain Act](#) (220 ILCS 75/20 (i)).
- Subject to IL law, after ICC issues written findings RE: applicant meets identified criteria and federal requirements.

As of September 18, 2023, there were two applications for Certificates of Authority to construct and/or operate CO₂ pipelines pending before ICC: Navigator Heartland Greenway, LLC (ICC Case No. [23-0161](#)) and Wolf Carbon Solutions, LLC (ICC Case No. [23-0475](#)).

Next intermediate hearings for each (not final decisions) currently scheduled for later October...

Looking Ahead: Safety and Siting

Mix of Federal and State Laws (and Local Opinions)

Safety Concerns:

Voiced in newspaper articles, media

Concerns expressed by stakeholders (interviewed for the [IL Carbon capture, utilization, and storage report](#)):

- Leakage of geologic storage sites
- Groundwater safety concerns
- Groundwater usage concerns
- CO₂ injection and storage causing earthquakes
- CO₂ migrating between pore spaces
- **CO₂ pipeline leakage, damage**
(e.g., Satartia, Mississippi/Denbury incident)
- CO₂ risk unknown because cannot adequately define or control pore space

Environmental Justice issues also related to safety and siting.

Potential for CCUS infrastructure to be co-located/nearer to EJ communities.

Public outreach necessary:

Proactive outreach with local communities

Response to questions – e.g. IL Lt. Governor asked ISGS about pipeline rupture in Mississippi

~~The future looks promising...~~

THE FUTURE IS NOW!

Research/Industry/Regulatory Developments and Discussion MRCI is Important

Acknowledgments:

US Department of Energy

Battelle

MRCI Members and Participants

Colleagues at the

Illinois State Geological Survey

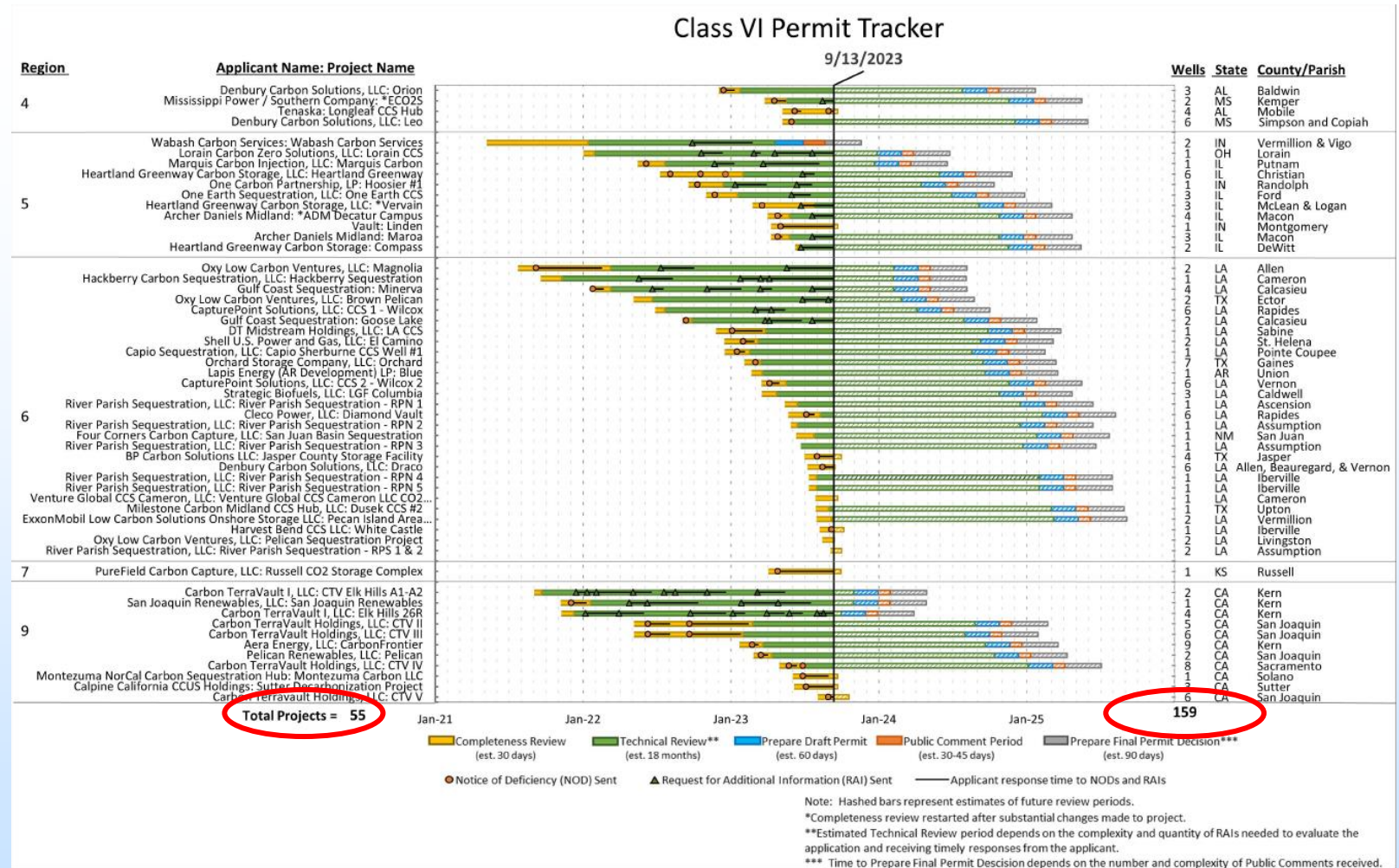
Illinois Sustainable Technology Center

Prairie Research Institute

Indiana Geological and Water Survey

Kentucky Geological Survey

Industry Partners



<https://www.epa.gov/uic/current-class-vi-projects-under-review-epa> (9/13/2023)

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