Carbon Capture and Storage in Illinois

Prairie Research Institute Briefing

August 30, 2021

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Briefing Agenda

11:00	**Welcome**	(Sen. Bill Cunningham, IL-18th)
11:05	**Overview of CCUS Report**	(Dr. Jeffrey Stein, PRI)
11:10	**Carbon Storage in IL**	(Dr. Sallie Greenberg, ISGS)
11:25	**Carbon Capture in IL**	(Dr. Kevin OBrien, ISTC)
11:40	**Q & A**	
12:00	**Adjourn**	

HB 165 – Carbon Capture Study

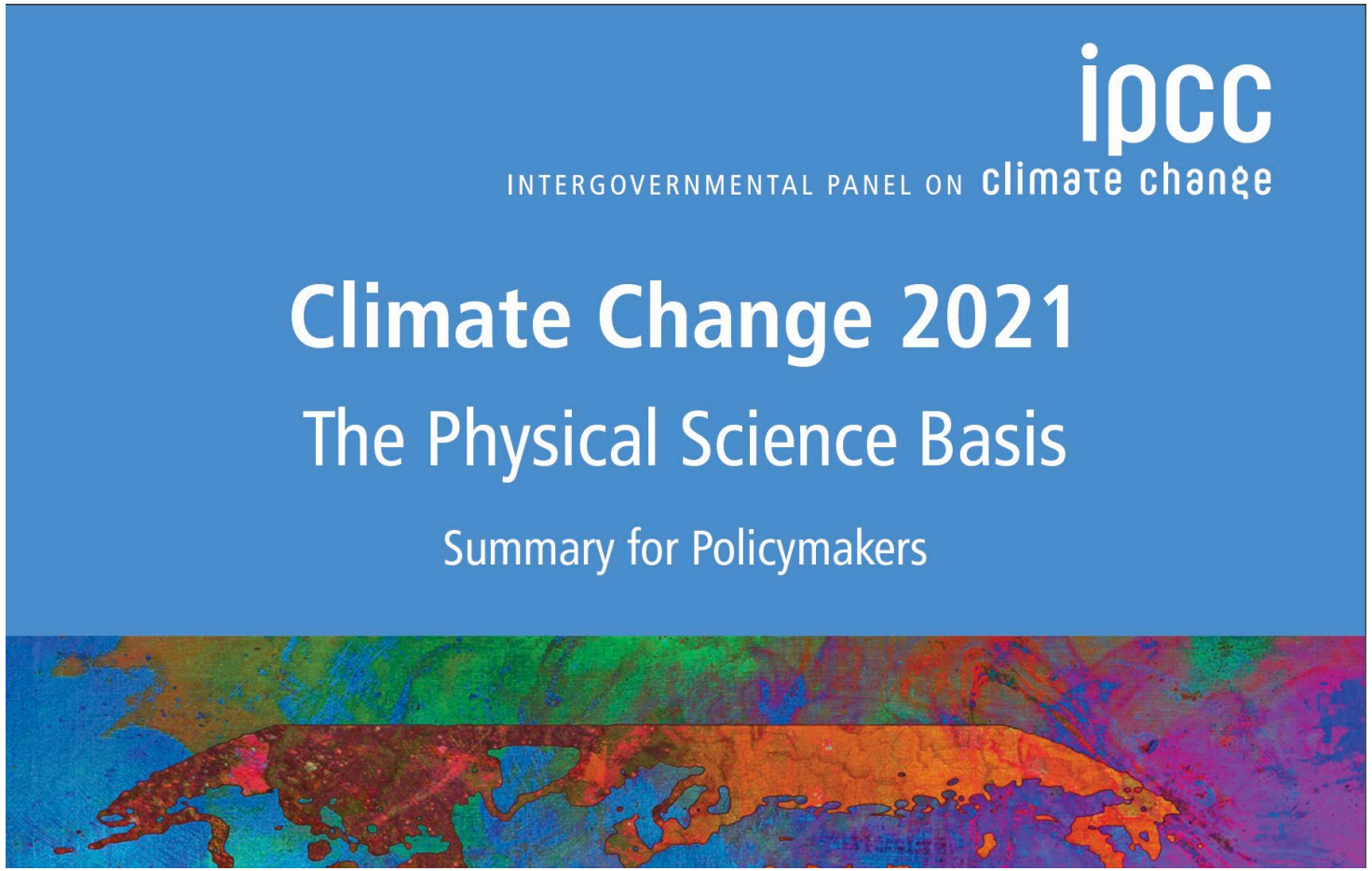
1. Report to Governor and General Assembly (by December 31, 2022)

2. Intergovernmental Advisory Committee (by October 12, 2021)

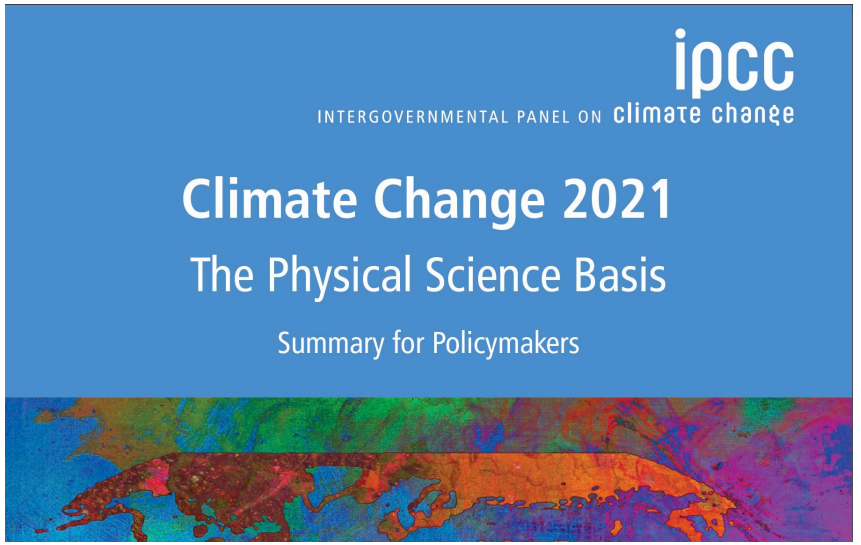
3. Engage Stakeholders for socio-economic perspectives

Why focus on CCUS?

All climate models require carbon capture, utilization and storage to meet reduction targets



High confidence in potential of CCUS



"Anthropogenic CO2 removal (CDR) has the **potential to remove CO2 from the atmosphere and durably store it in reservoirs** (*high confidence*). CDR aims to **compensate for residual emissions to reach net zero CO2** or net zero GHG emissions or, if implemented at a scale where anthropogenic removals exceed anthropogenic emissions, to lower surface temperature."

(D.1.4, SPM-39)

Introduction to Carbon Storage
What has Illinois done?

Sallie E. Greenberg, Ph.D.

University of Illinois – Illinois State Geological Survey

30 August 2021

Illinois Delegation Zoom Presentation

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Why Illinois? Why Now?

Exceptional Geology

Globally recognized leader in research for capture, utilization, and storage

Federal and State Policy drivers

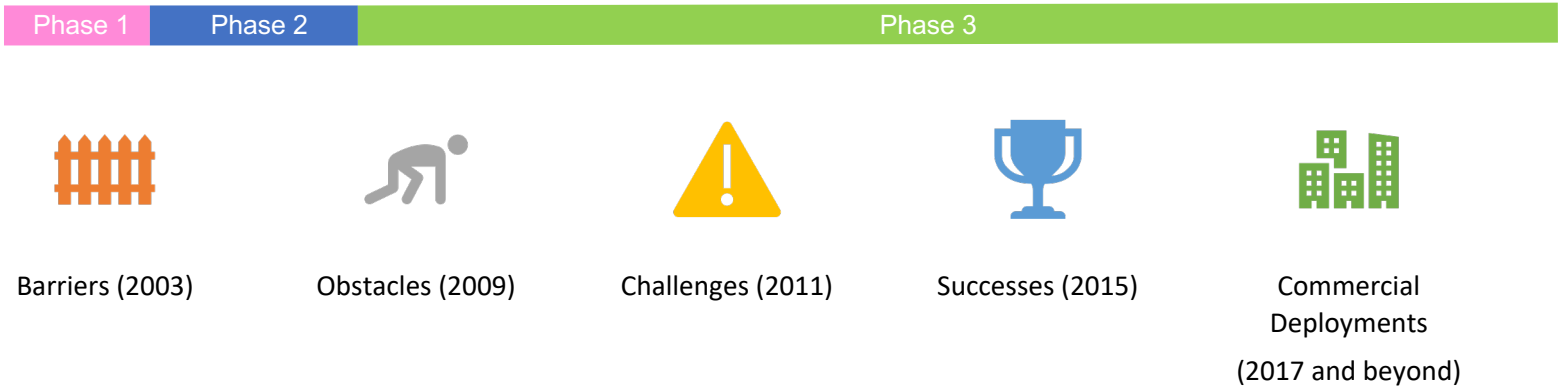
Incentives

- 45Q Tax Credit
  - Provides $50/ton for saline storage, $35/ton for EOR (enhanced oil recovery)
  - Begin construction before 1/1/2026
  - 12-year period, up to 75 million tons
  - Transferrable along value chain

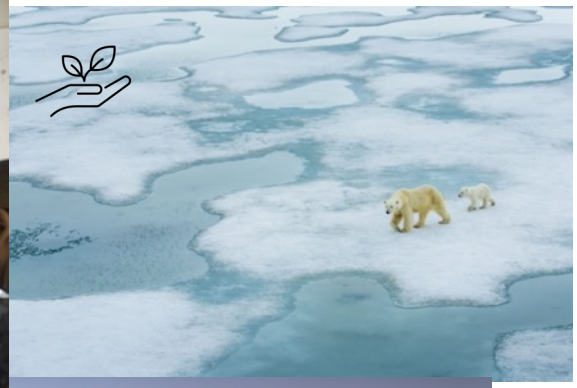
Infrastructure, jobs, economics

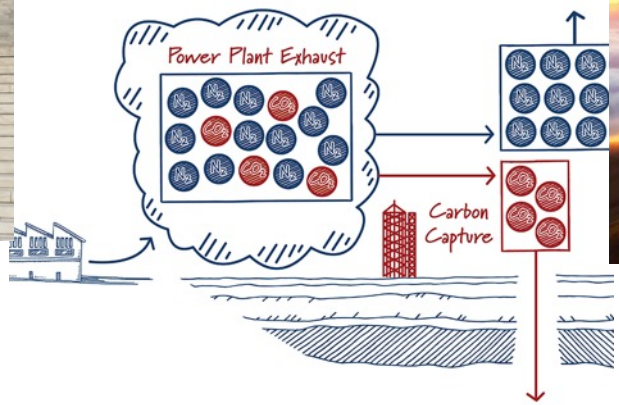
Throughout the world scientists, governments, and industrial partners are working together to demonstrate Safe and Effective carbon management.

The pieces continue to come together…and Illinois is central to our understanding.

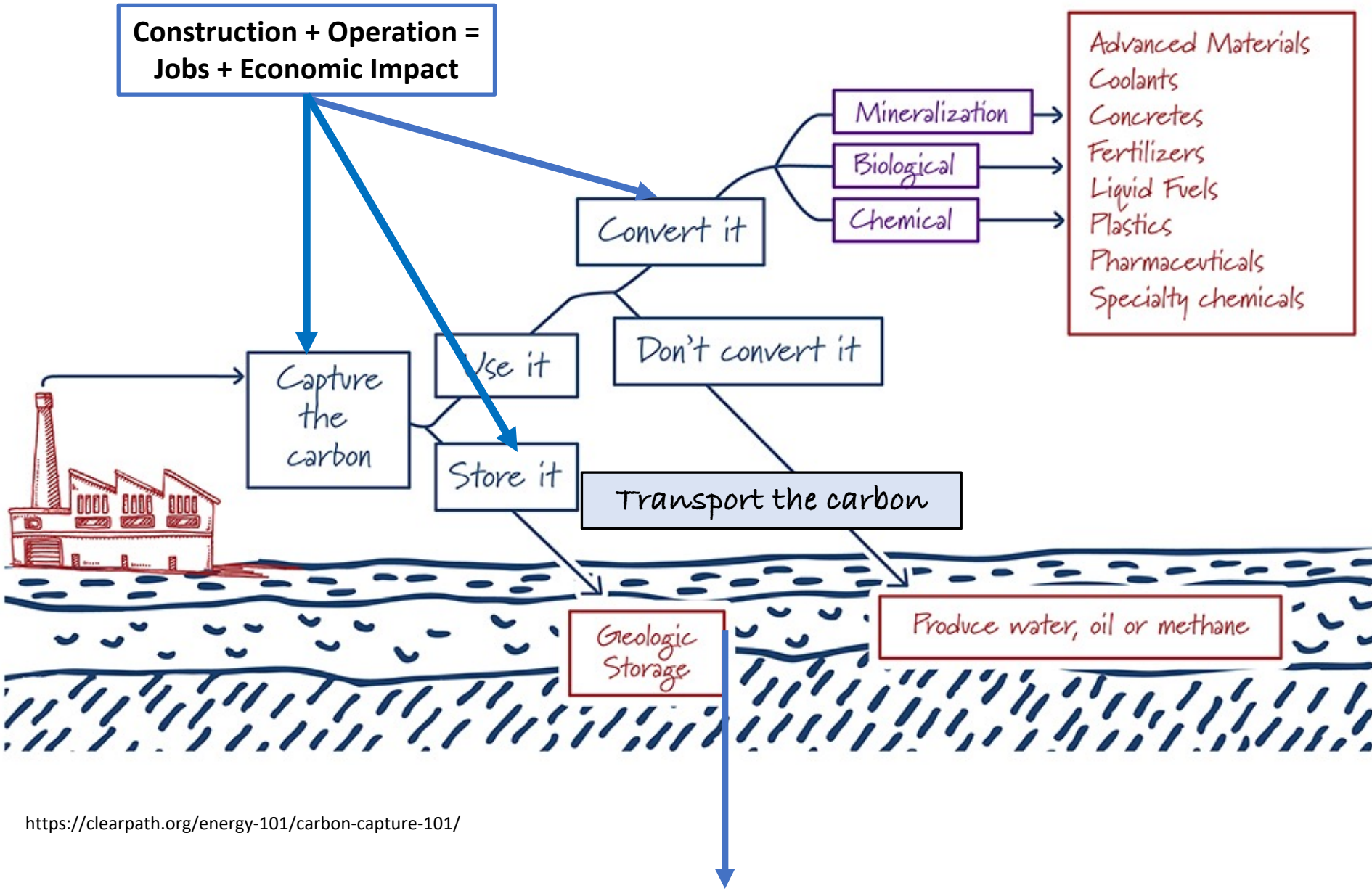



61.6 %: 99.19
104.19
86.72
72.48



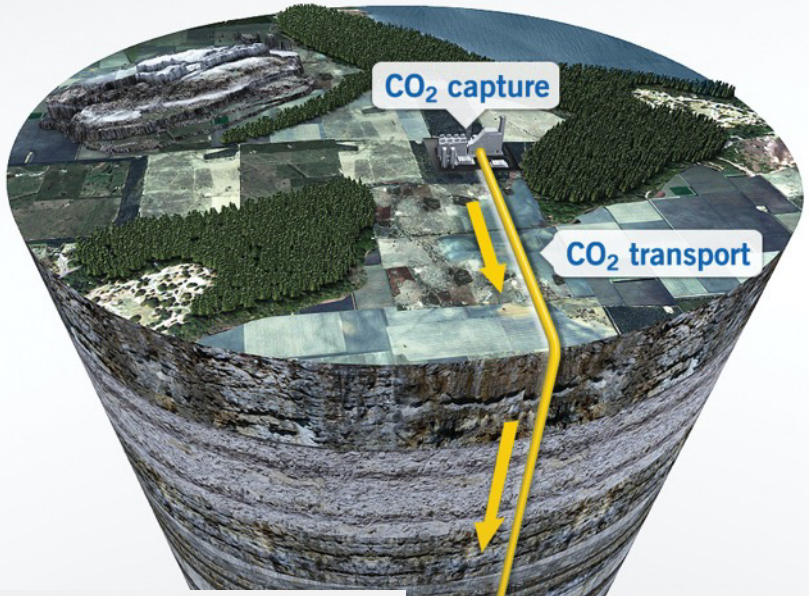

Power Plant Exhaust
Carbon Capture

CCUS: A Job and Economic Impact Multiplier



https://clearpath.org/energy-101/carbon-capture-101/

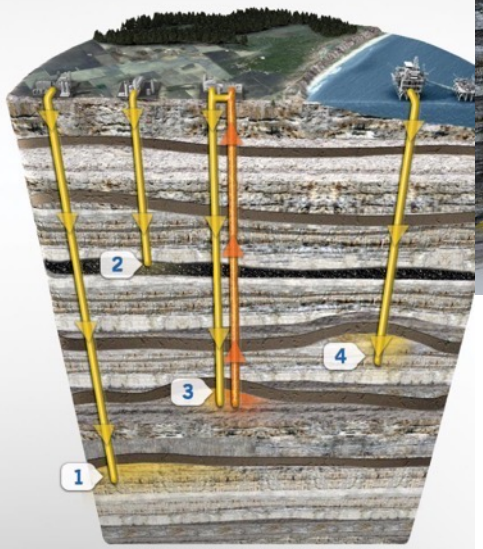
THE CARBON CAPTURE AND STORAGE PROCESS



STORAGE OVERVIEW

SITE OPTIONS

1. Saline formations
2. Injection into deep unmineable coal seams or ECBM
3. Use of CO_2 in enhanced oil recovery
4. Depleted oil and gas reservoirs



Provided by the Global CCS Institute

Figures from Global CCS Institute

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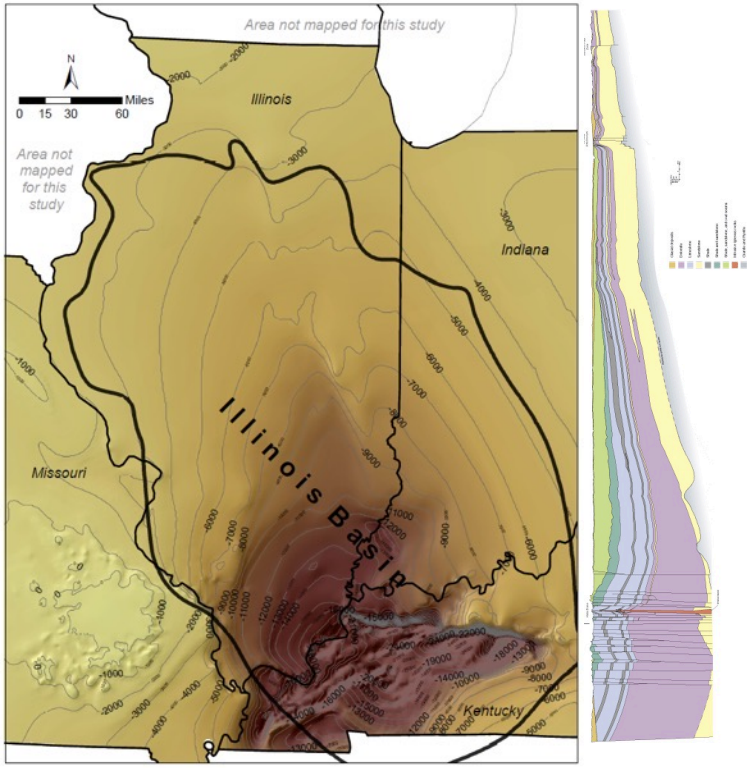
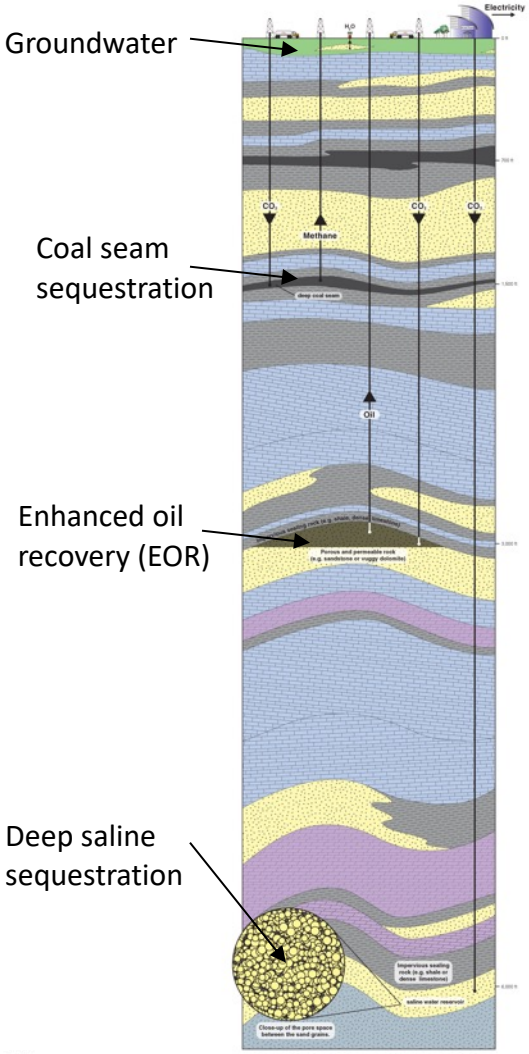
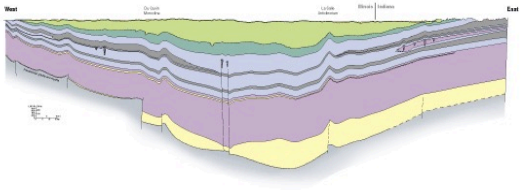
Principles of Geologic Storage

- Earth stores water, saline water, oil, and natural gas in pore spaces of rock units
- Storage uses the Earth's natural trapping system to store CO_2
- Porous rocks act as Sinks (storage units)
- Impermeable rocks act as Seals (caprock units) providing protection



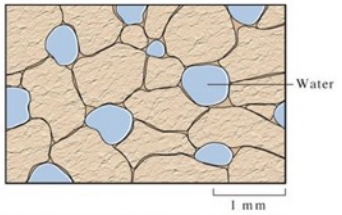




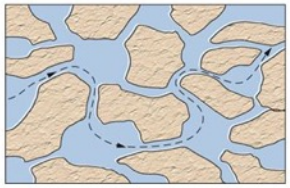
Key Geologic Concepts

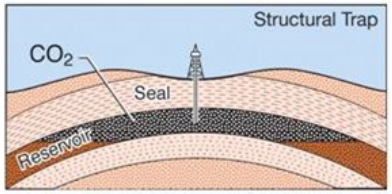
- Injectivity – can you put CO_2 in the rock?
- Capacity – how much CO_2 can you put in the rock?
- Containment – can you keep the CO_2 in the rock?
- Production – can you get a useable commodity from the rock?

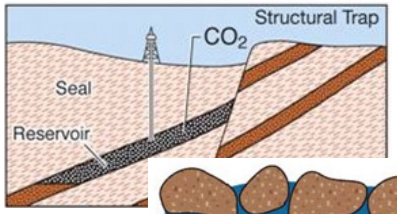
Porosity



Permeability







Trappin
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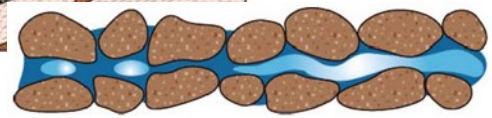
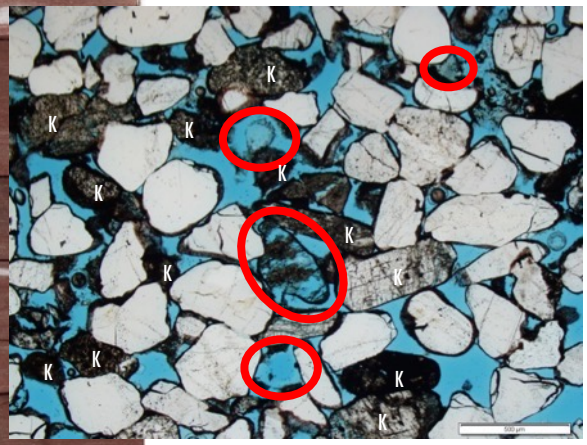
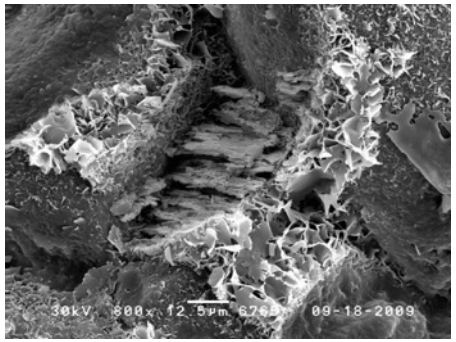


Sandstones act as Storage Formations





Shale and Tight Sandstones act as Seals

Mt. Simon Mudstone

Eau Claire Shale

Maquoketa Shale

New Albany Shale

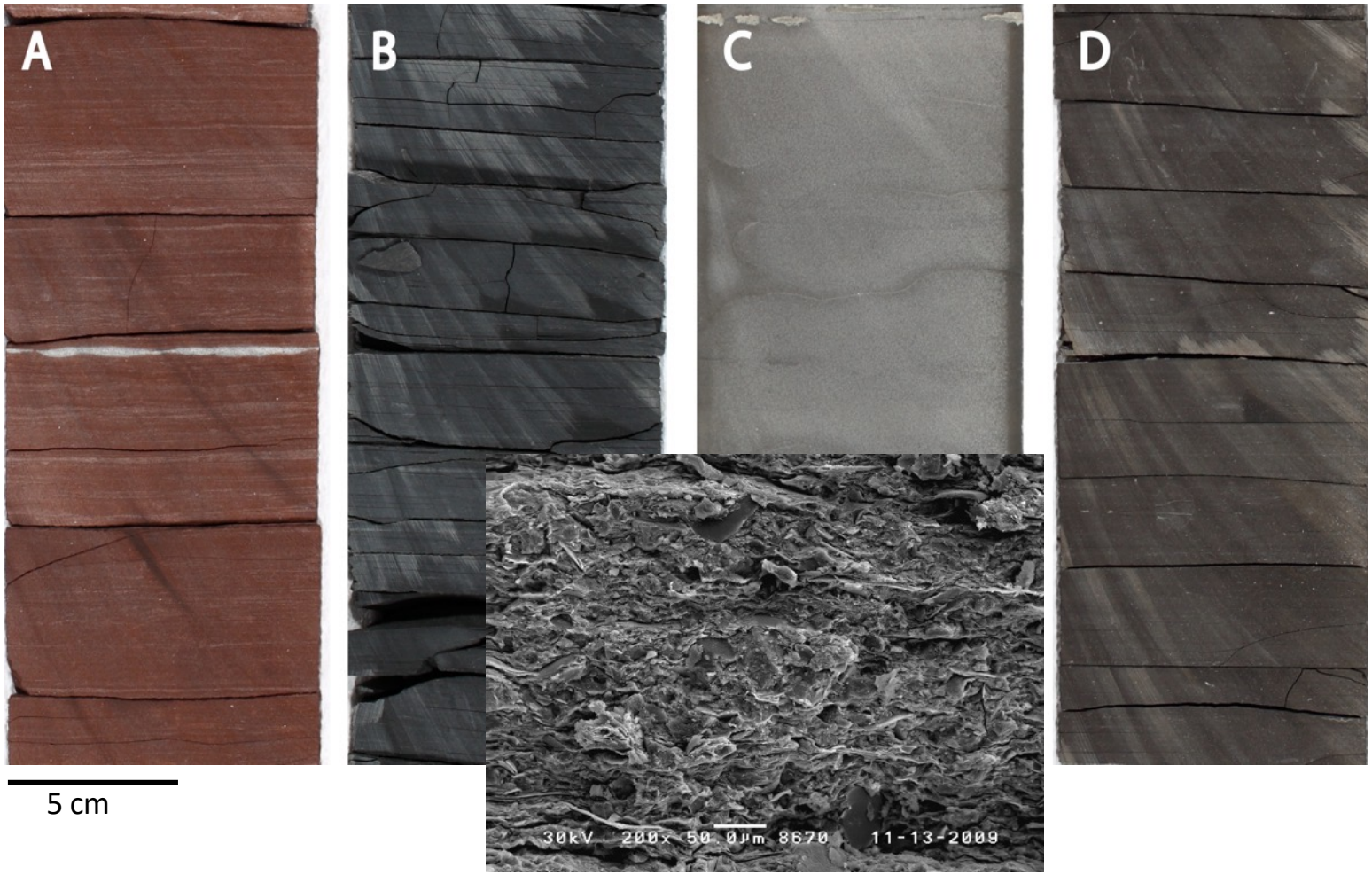
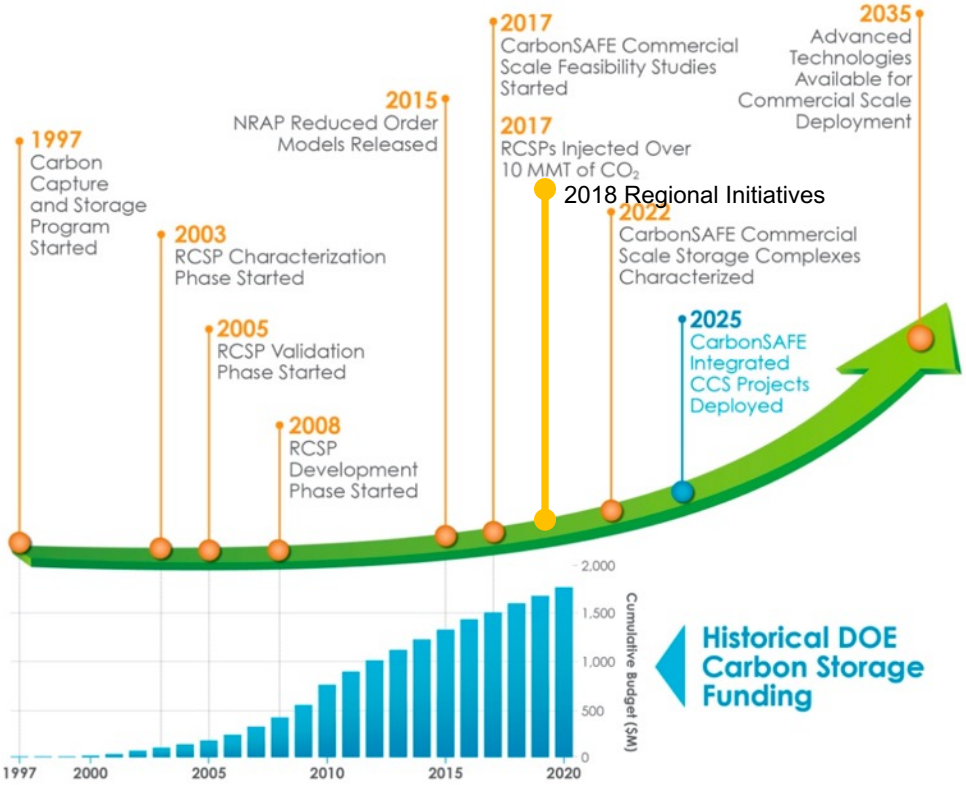
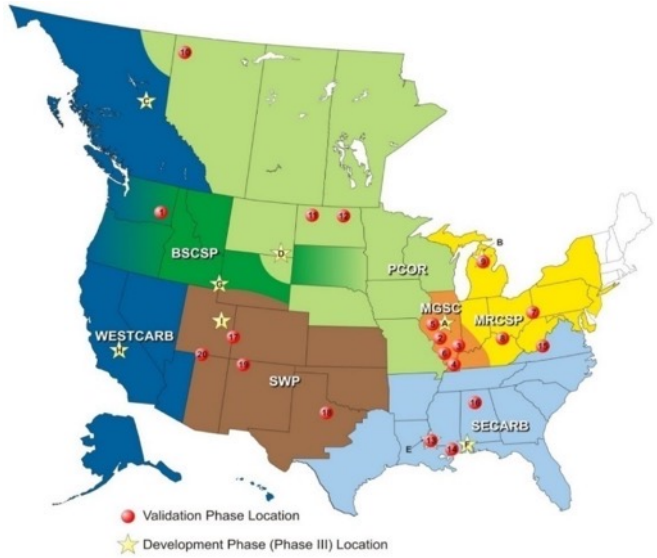


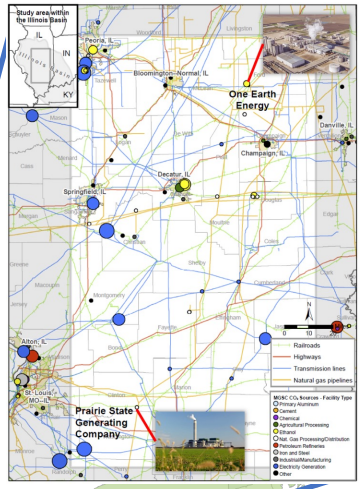
Exhibit 2-1. Cumulative investment and milestones toward achieving technology readiness for widespread commercial-scale deployment





STORAGE PROGRAM FIELD Initiatives AND CAPTURE PROGRAM FEED STUDIES

Four Re-envisioned Regional Partnerships
Five CarbonSAFE Phase III Projects



Minnkota Power Cooperative, Inc.
Milton R. Young Unit 2, ND

Membrane Technology and Research, Inc.
Basic Electric Dry Fork Station, WY

Ion Engineering, LLC
Nebraska Public Power District
Gerald Gentlemans Station Unit 2, NE

EPRI
Elk Hills Power Plant, CA

Enchant Energy, LLC
San Juan Generation Station, NM

PCOR Initiative

Carbon Utilization and Storage Partnership

Midwest Regional Carbon Initiative

SECARB-USA

Board of Trustees for the University of Illinois
Prairie State Generating Company's Energy, IL

University of Texas at Austin
Golden Spread Electric Cooperative Mustang, TX

Bechtel National, Inc.
Panda Power Funds, TX

Southern Company Services, Inc.
Plant Daniels 3&4, MS
or
Plant Barry 6&7, AL

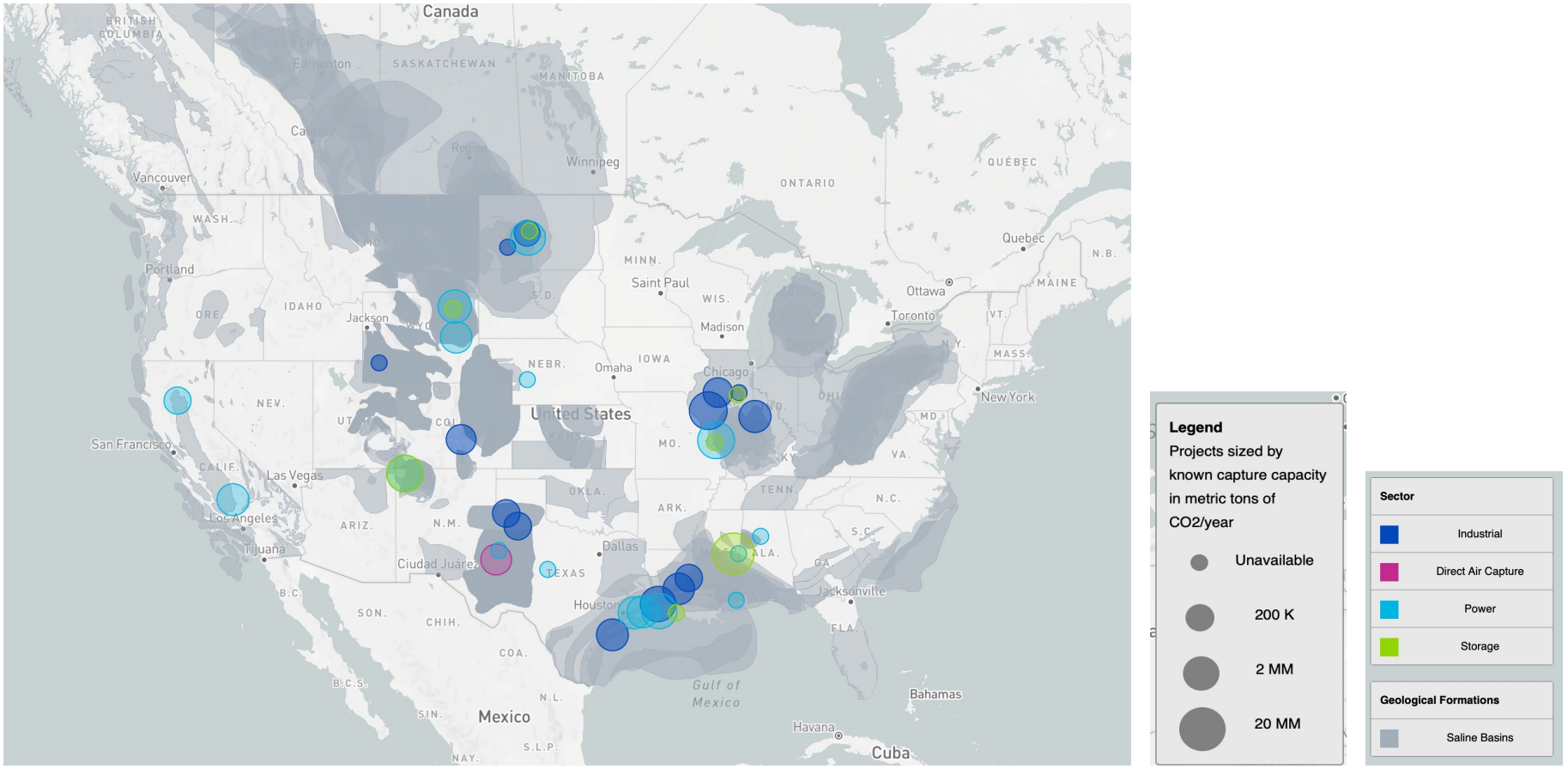
Capture Program FEED Studies

- Coal
- Natural Gas

CarbonSAFE Phase III Projects (Awards Pending)

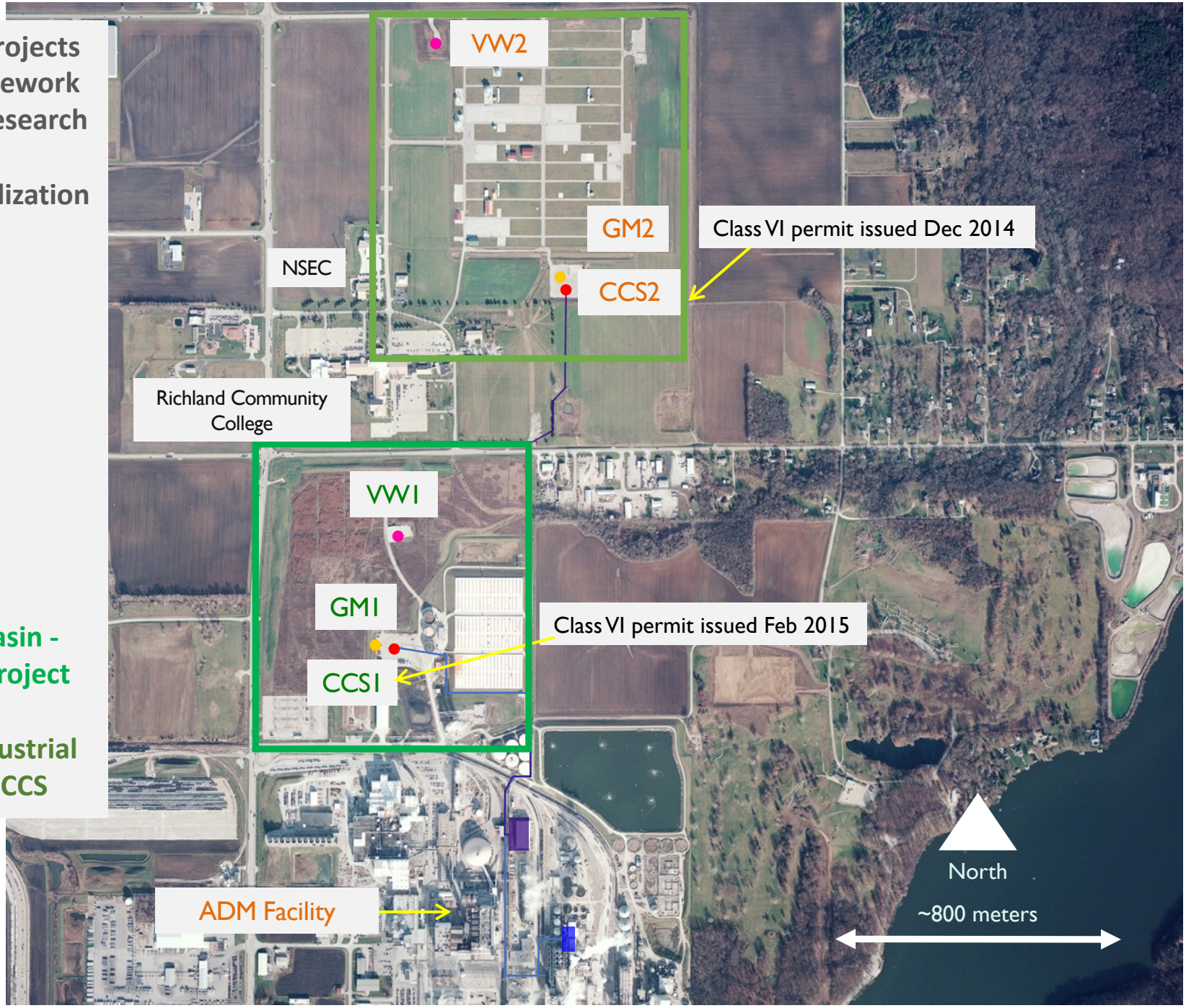
1. North Dakota CarbonSAFE Phase III: Site Characterization and Permitting (UNDEERC)
2. Wyoming CarbonSAFE: Accelerating CCUS at Dry Fork Power Station (UofW)
3. Illinois Storage Corridor (Univ. of Illinois)
4. Establishing an Early CO2 Storage Complex in Kemper County, Mississippi: Project ECO2S (SSEB)
5. San Juan Basin CarbonSAFE Phase III: Ensuring Safe Subsurface Storage of CO2 in Saline Reservoirs

Answering the Question of Where is storage viable?



https://www.catf.us/2020/07/ccus-interactive-map/

Multiple Projects Build Framework for CCUS Research and Commercialization



Illinois Basin - Decatur Project

Illinois Industrial Sources CCS

Demonstrating carbon management: CCUS Projects in Decatur, IL USA

Illinois Basin – Decatur Project

- Large-scale demonstration
- Volume: 1 million tonnes
- Injection period: 3 years
- Injection rate: 1,000 tonnes/d
- Compression capacity: 1,100 tonnes/day

Contribution:

- Geologic and Social Site Characterization
- Reservoir Modeling and Risk Assessment
- MVA Development and Engineering Design
- Stakeholder Engagement

Status:

- Post-injection monitoring ends April 2020
- Conceptual site model and history matching

Illinois Industrial CCS Project

- Industrial-scale demonstration
- Volume: up to 5 million tonnes
- Injection period: 3 years (or longer)
- Injection rate: 3,000 tons/d
- Compression capacity: 2,200 tonnes/day

Contribution:

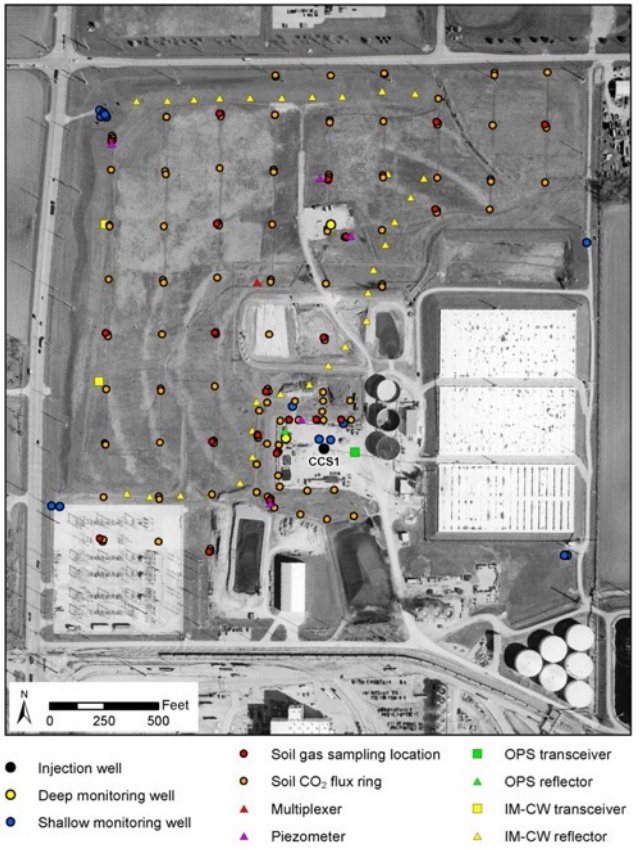
- Commercial-scale up surface and subsurface
- Intelligent Monitoring
- Class VI permitting

Status:

- Injection Began April 7, 2017
- Optimization of capture process
- ~2,400,000 (as of June 2021)

Carbon Storage: Demonstrated Technology

- Captured, transported, stored, and monitored 1 million tonnes of CO_2 from biofuel production in an onshore Saline Reservoir
- First-of-a-kind monitoring, verification, and accounting program
- Met and exceeded all technical and non-technical challenges
- Successful Class VI permitting
- Conducted microseismic monitoring and interpretation
- Developed International collaborations
- Laid foundations for multiple projects
- Build international, national, and regional capacity
- Stakeholder engagement strategy built trusted relationships
- Created comprehensive data set



IBDP by the numbers (IBDP + ICCS):

- 3+ million tonnes CO_2 stored from **biofuels**
- More than **5,000 meters** of drilled wells
- More than **245 meters** of collected core
- Near-surface groundwater monitoring efforts have resulted in more than **60,000 analyses**
- For basin-scale modeling, we will use **1,020,000 CPU-hours** of XSEDE supercomputing resources.
- More than **1,700 visitors from 29 countries** have been to IBDP and ICCS
- More than **100 people from at least 10 organizations** have worked together to make these projects a success

Carbon Storage Progression in Illinois Basin

CarbonSAFE Illinois

ILLINOIS Industrial Carbon Capture & Storage

MGSC

IBDP: 1 MT Demonstration

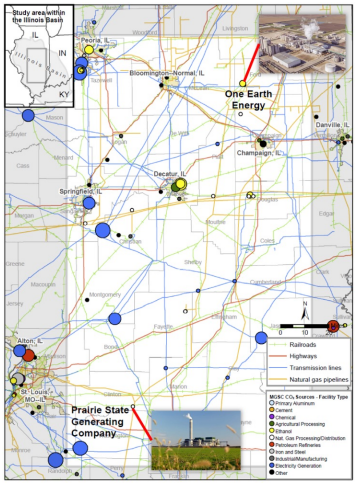
ICCS: 3 - 5.5 MT Industry Site

CarbonSAFE Illinois: Phase 1

CarbonSAFE Illinois: Phase 2 >50 MT Feasibility

CarbonSAFE Phase 3 Injection Permitting

MRCI Midwest Regional Carbon Initiative



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U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

Key Learnings

- Geology is critical and will always remain key factor
- Iterative scientific investigation allows for advancement and economy of scale
- Baseline environmental assessments are critical
- Unanticipated results provide insights into improvements that benefit all projects
- Incorporate technology changes into life cycle of project
- Simplicity is key success factor
- Scientific and engineering timeframe not aligned with policy
- Pilot and demonstration projects provide critical insights
- Policy drivers are necessary to facilitate commercialization
- Regulatory, legal, and social factors require significant time investment

Questions?

Sallie Greenberg - sallieg@Illinois.edu

Illinois: Leader in Reducing / Preventing CO_2 Emissions through Carbon Capture Utilization and Storage (CCUS)

Kevin C. OBrien, PhD
Director, Illinois Sustainable Technology Center
Director, Illinois State Water Survey

kcobrien@Illinois.edu

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Disclaimer

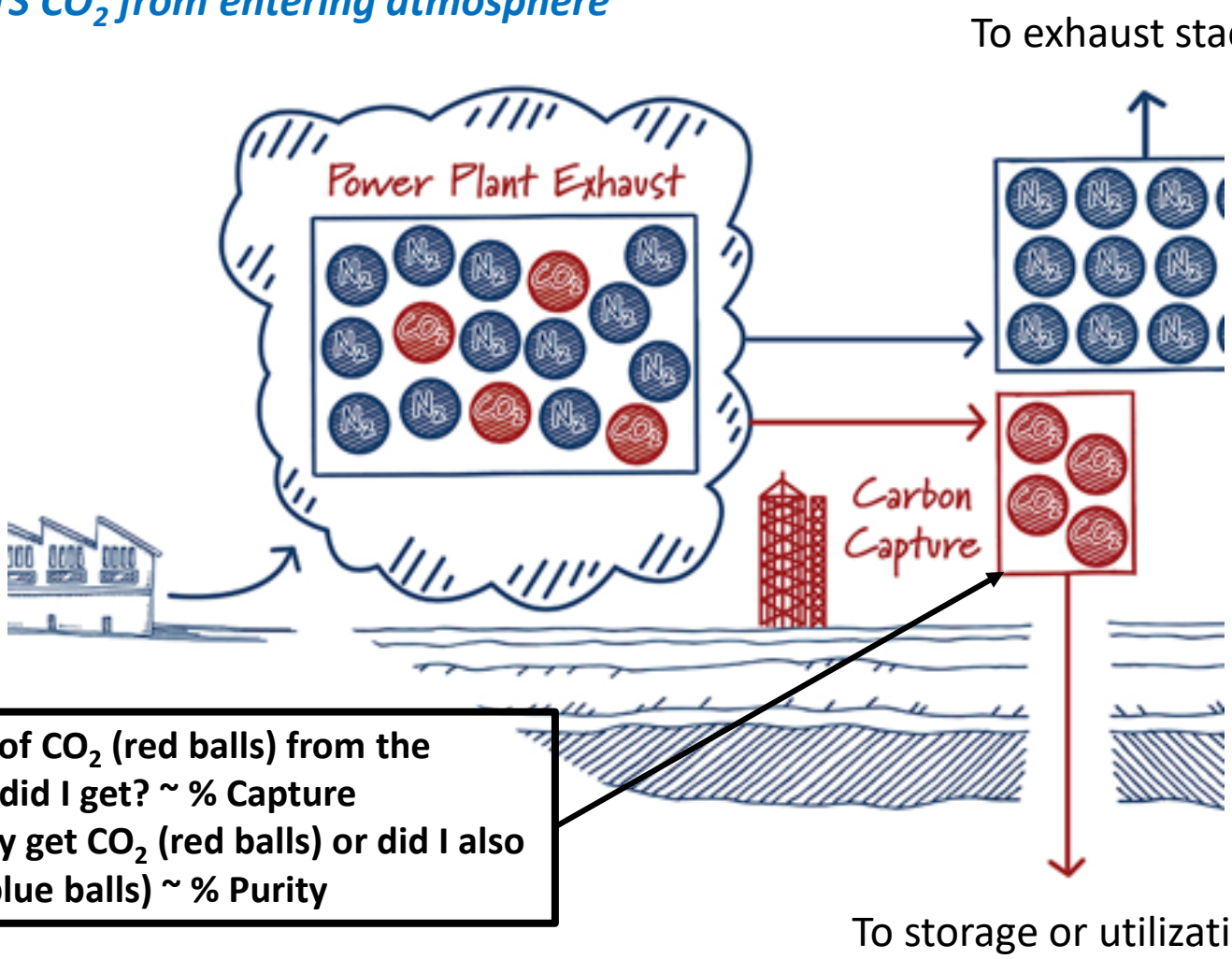
What is CCUS?

Ability to store CO_2 locally drives the interest in carbon capture

- **C**arbon (CO_2) **C**apture from the exhaust gas from powerplants and industrial facilities
  - Accomplished through the use of solvents, membranes, or sorbents
- **U**tilize the carbon for a revenue stream (examples)
  - Utilize to grow algae and then make:
    - Animal feed, biochar (soil), biofuels
  - Utilize to make chemicals
    - Dimethyl Carbonate (DMC) used in batteries for electric cars, etc.
  - Tax credits (45Q) generated
- **S**torage of the CO_2 (geological)
  - Tax credits (45Q) generated

What is Carbon Capture?

PREVENTS CO_2 from entering atmosphere



- **What % of CO_2 (red balls) from the exhaust did I get? ~ % Capture**
- **Did I only get CO_2 (red balls) or did I also get N_2 (blue balls) ~ % Purity**

https://clearpath.org/energy-101/carbon-capture-101/

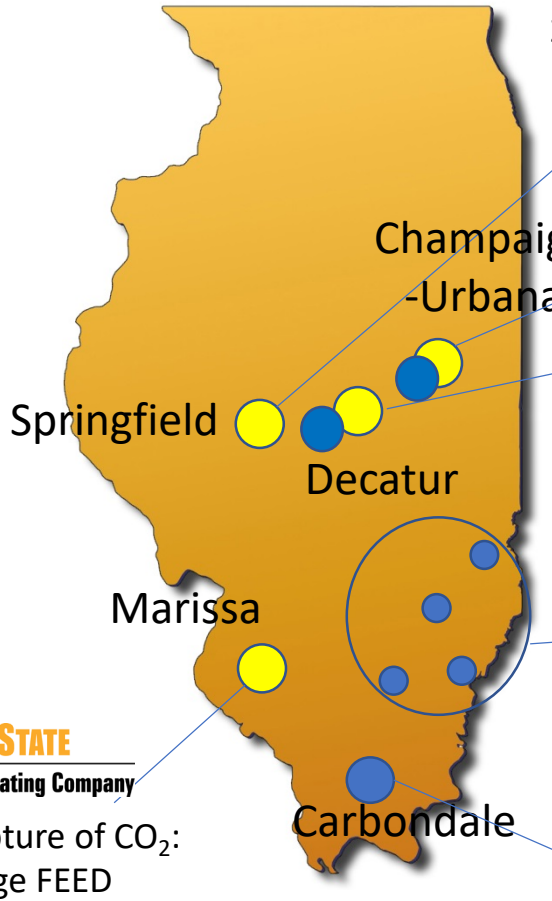
Does Carbon Capture Work?

Targets for % capture and purity of CO_2 produced have been met

- Targets for capture systems established by the US Department of Energy (DOE)
  - Minimum of 90% Capture of CO_2 emissions
  - Minimum 95% purity of CO_2 produced
- Focus is on retrofitting existing power plants and industrial facilities with carbon capture systems
- Current federal administration and congress has established that carbon capture and CCUS is one of the main tools to reduce CO_2 emissions at a national level
- Internationally carbon capture and CCUS is also one of the main tools to reduce CO_2 emissions
- 45Q federal tax credits are an economic driver

Illinois: Largest Number of Active Projects in CCUS

Creates global leadership in grid decarbonization using CCUS



Capture of CO_2 : Phase III Large Pilot (10 MW)
21st Century Powerplant (350 MW)/ capture /energy storage/algae

Capture of CO_2 (0.5 MW and 40 kW)
Energy Storage (400 MWh)

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Champaign -Urbana

Springfield

Decatur

Marissa

Storage of CO_2 : ADM Project

Illinois Eastern Community Colleges
Operator Training

Fairfield,Olney, Robinson, Mt. Carmel

PRAIRIE STATE Generating Company

Capture of CO_2: Large FEED (+800 MW)

Carbondale

Southern Illinois University Carbondale

Existing projects

Educational Resources

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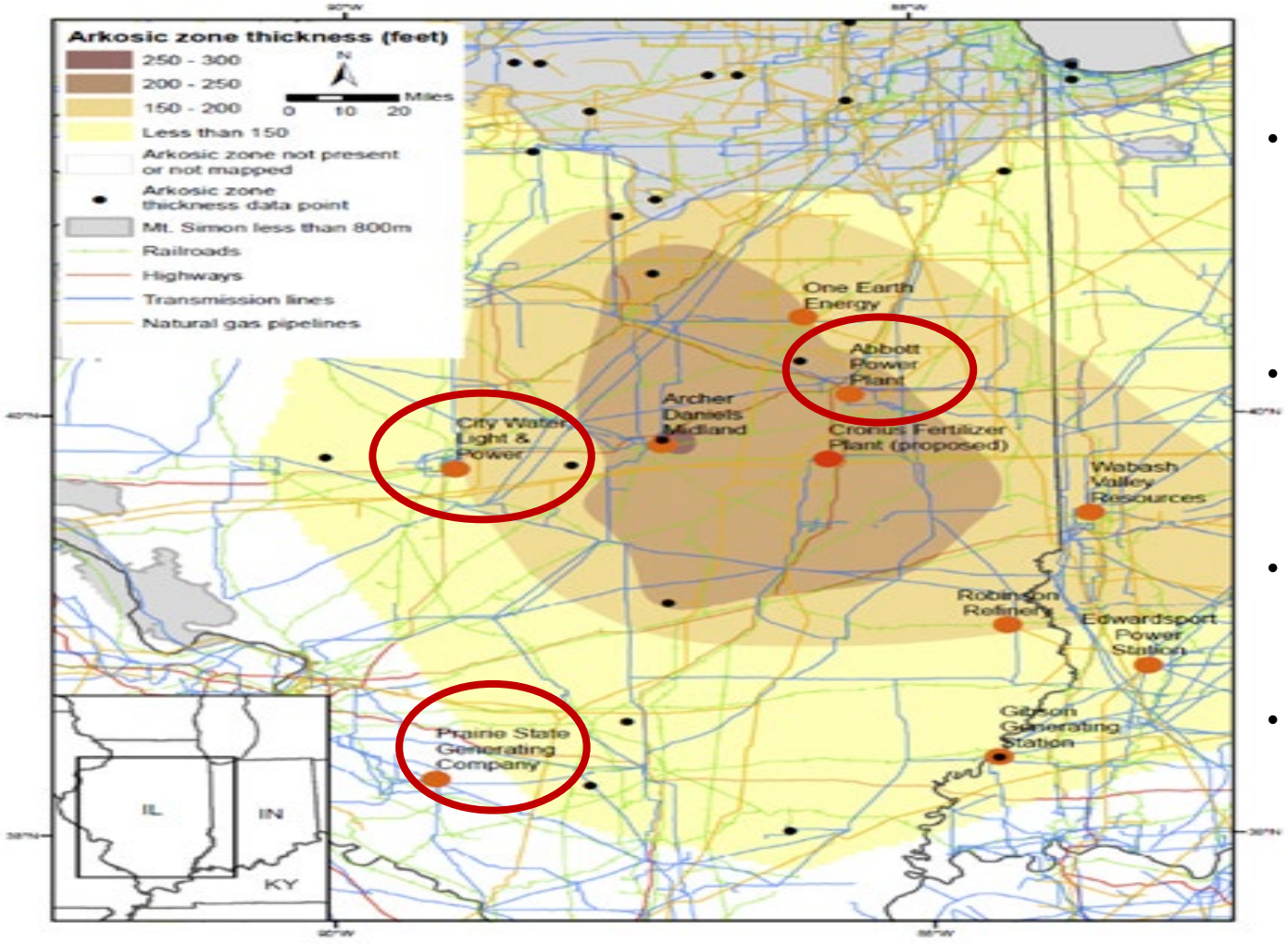
Capture Studies Coordinated with Geological Storage

CarbonSAFE Phase III: Geological Storage



- ***Able to connect to CarbonSAFE's Phase III Illinois Geological Storage Corridor***
- ***Sufficient CO_2 Geological Storage Capacity Near the Host Sites***
- ***All sites within 100 miles of storage site***
- ***Immediate access to Interstate highway***

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Portfolio of Projects to Reduce and Utilize CO_2 Emissions

Illinois is the leader in diverse portfolio

Abbott Power Plant
City, Water, Light & Power
Prairie State Generating Station
Various locations

Lab	Small Pilot	Large Pilot / Full Scale
		816 MW FEED
	0.5 MW Aerosol Reduction	
	0.5 MW Capture w/Mixed Salts	10 MW – Build / Operate Large Capture Pilot
Next generation DAC materials	40 kW Capture - Biphasic Solvent	350 MW – FEED w/ Capture, energy storage, algae, hybrid coal/NG
		+400 MWh pre-FEED energy storage using NG
	Water Recycle and Reuse	Direct Air Capture (DAC) FEED 100,000 tCO2/yr
		Algae cultivation for wastewater treatment & biofuels FEED

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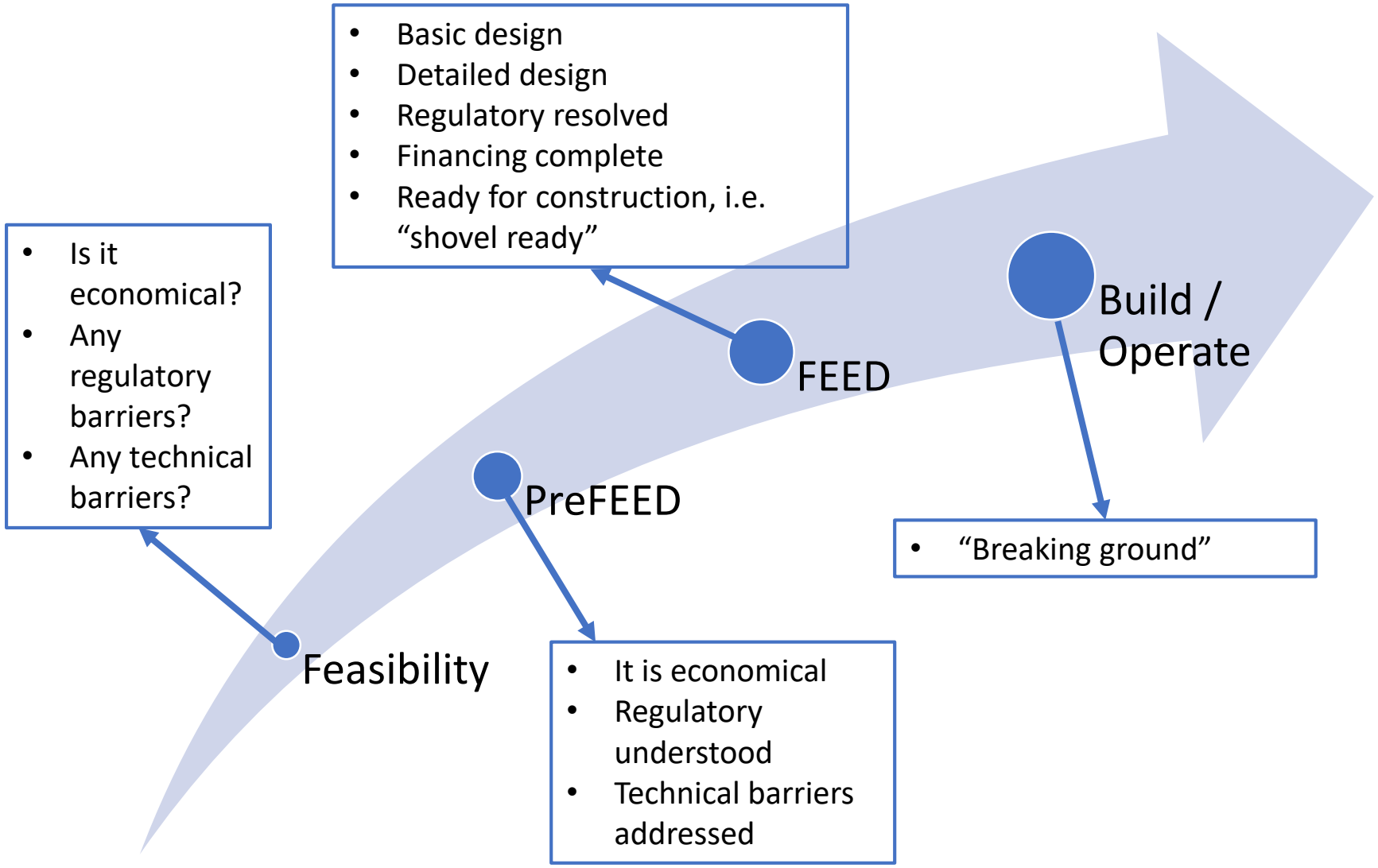
Pathway for Large Pilots / Full Scale Capture Projects

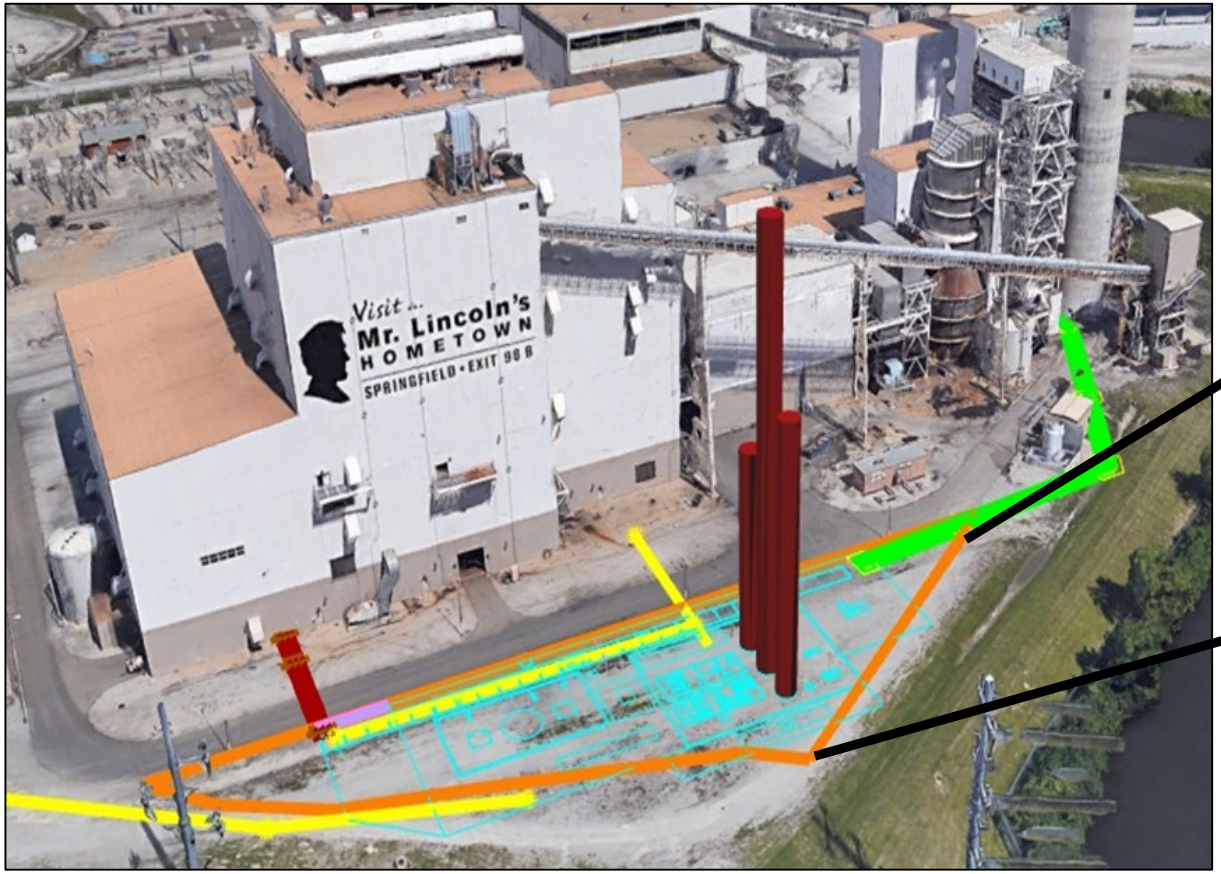


City, Water, Light, and Power

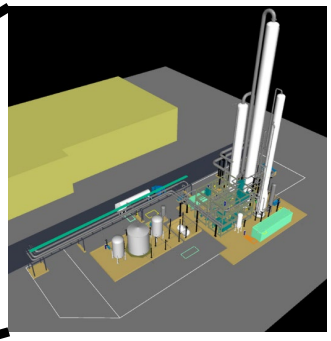
- Build / Operate: Largest Capture R&D Pilot in the World (10 MW)
- FEED: 21st Century Power Plant (350 MW) that incorporates Hybrid natural gas-coal; energy storage, capture, CO_2 utilization (algae)

City Water, Light and Power (CWLP)

Project at Dallman #4 Unit



Detailed design of capture facility



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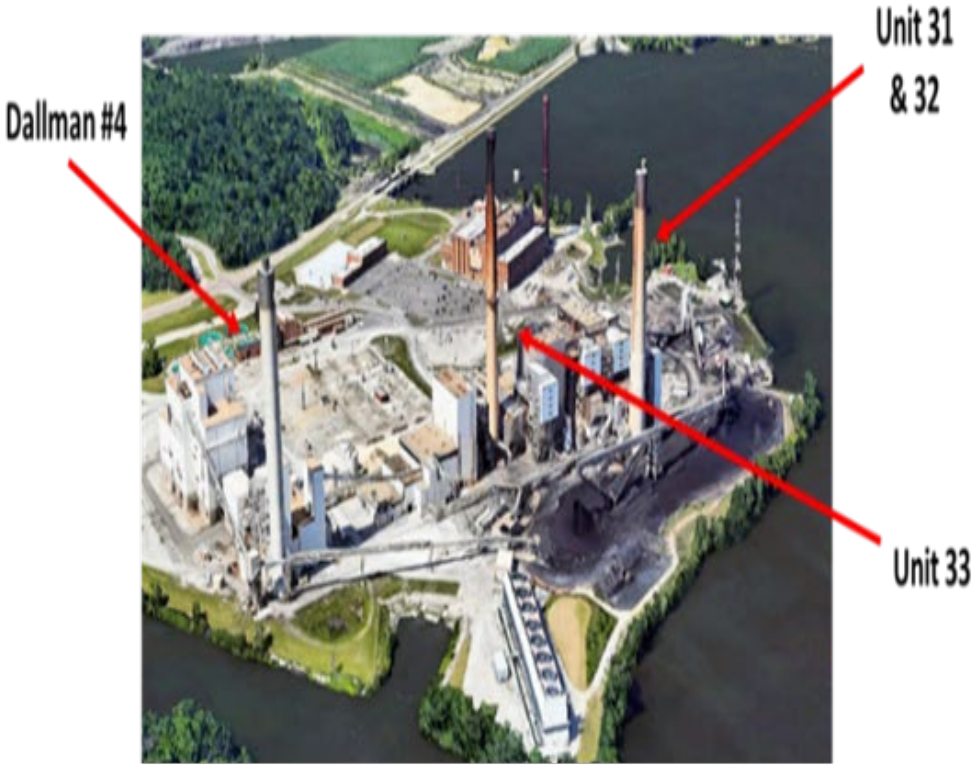
21st Century Power Plant Project at CWLP

CWLP as Host Site Leverages Other DOE Projects



Figures (a) Four coal-fired units at CWLP; ***(b) Space available for 21st Century Power Plant***

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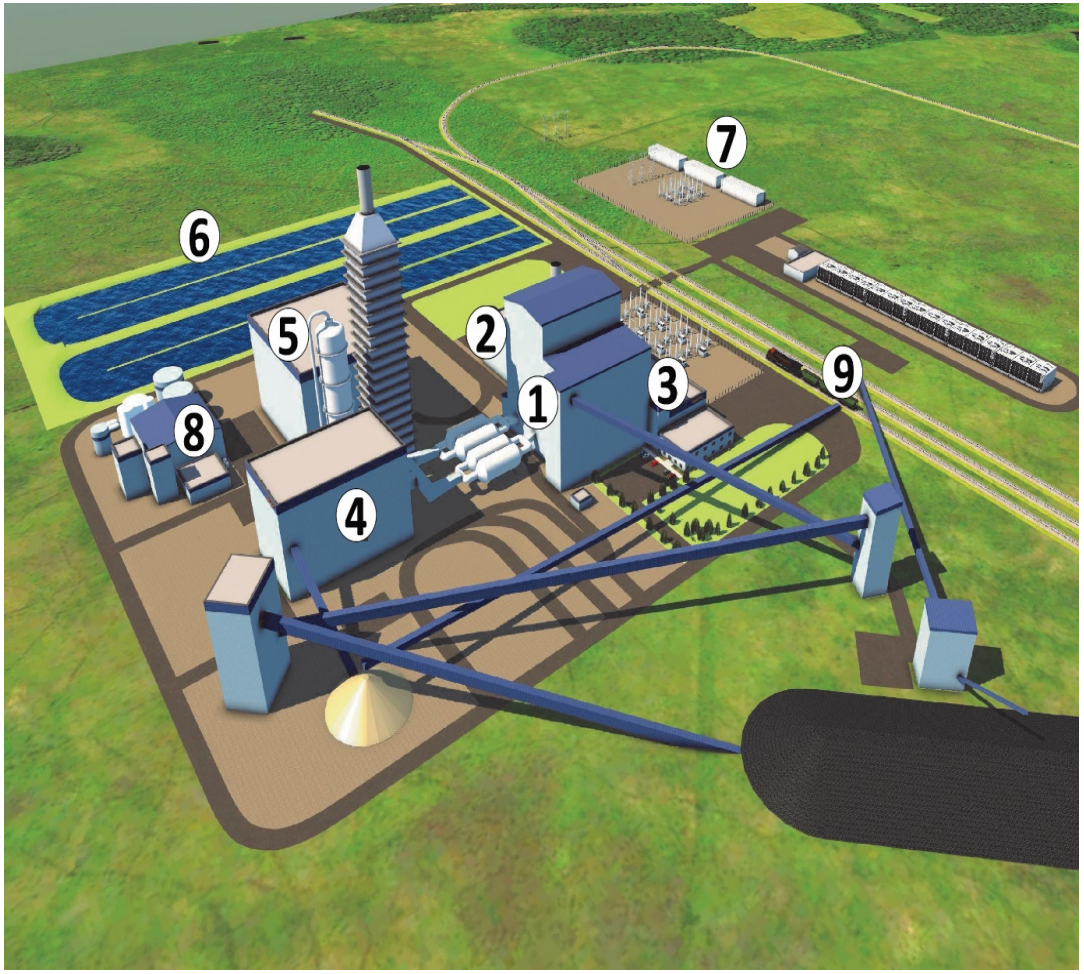
Integrated Power Plant for the 21st Century at CWLP



1. Boiler
2. Combustion Turbine Generator (CTG) Package
3. Steam Turbine Generator (STG) package
4. Air Quality Control System (AQSC)
5. Carbon Capture
6. Algae Based CO_2 Utilization
7. Energy Storage
8. Water Treatment
9. Coal Receiving, Storage, and Handling.

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Illinois: National and Global Leader in CCUS

Geology and capture projects provide major advantage to the state

- CCUS is REQUIRED to prevent / reduce CO_2 emissions globally
- Carbon capture WORKS and ACHIEVES desired performance goals
- CO_2 CAN be monetized through 45Q and the utilization of CO_2
- Unique Geology of Illinois major asset for CO_2 Storage
- Illinois is a national and global leader in CCUS
- Illinois is a leader in intellectual resources for CCUS
- CCUS not only reduces CO_2 emissions but can also create jobs and drive regional economic growth through multiple sectors

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