Carbon Capture and Storage (CCS)

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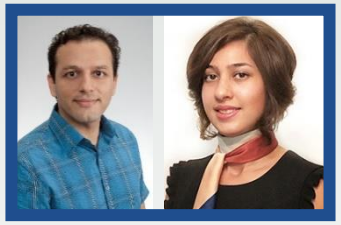
The Gulf Coast Carbon Center (GCCC)

- **Largest research group** devoted to the topic in the US; **globally recognized**.
- **Applied Research** – 1-3 year outlook
- **Enabling the private sector to develop an economically viable industry** to store CO_2 in the Gulf of Mexico, across the U.S., and globally
- **Educating all stakeholders** – industry, regulatory, policy, public, etc.

Fluid Flow Modeling



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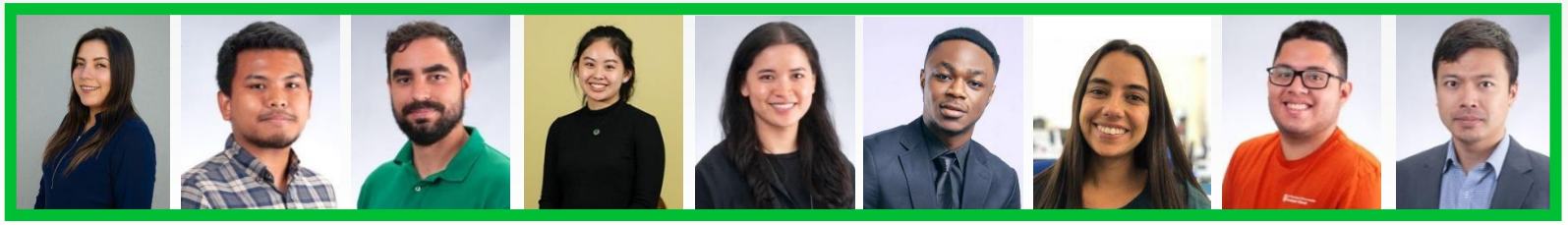

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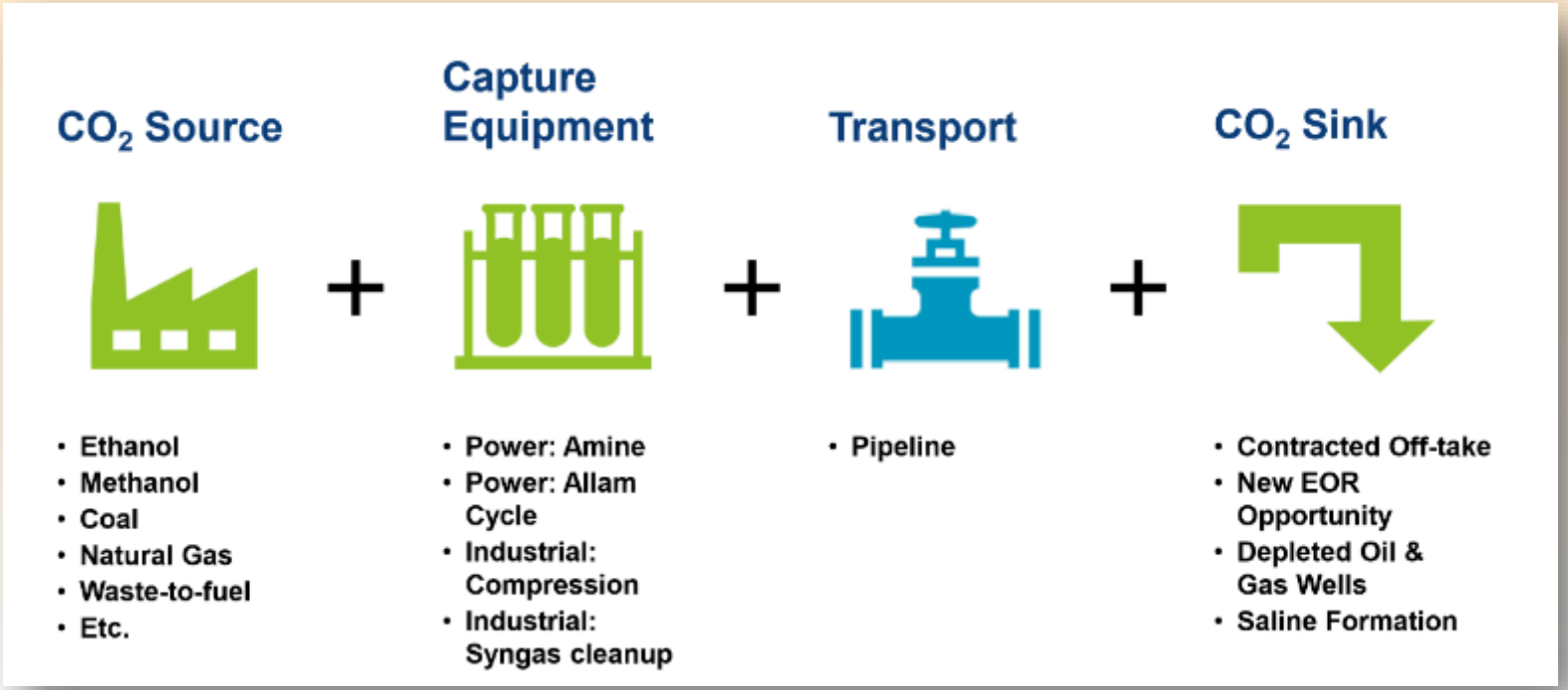
Current GCCC Sponsors

Key Points

- Carbon Capture Utilzation and Storage (CCUS) is not a new topic.
- CCUS basics: Capture, Transport, Storage.
- Deployment focus is on emission hubs, including marine ports.
- Economics are rooted in tax credits

CCUS Components

The CCuS business is evolving, but at its core, it will likely be populated by emissions sources, service and technology providers, midstream transport, well and storage operators, and tax equity driven project investors / developers.



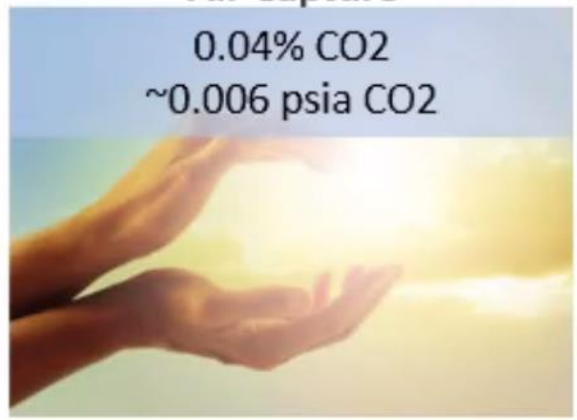
+ DAC, Fuel Cell **+ Ship**

CO_2 Management Addresses Diverse Sources, and the CO_2 Concentration Affects Technical and Cost Challenges

Coal Power Plant

Gas Power Plant

Air Capture

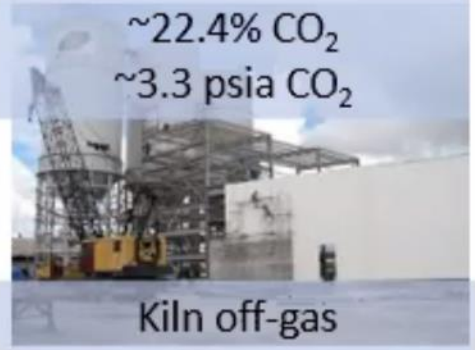


NG Processing Plant

Ammonia Plant

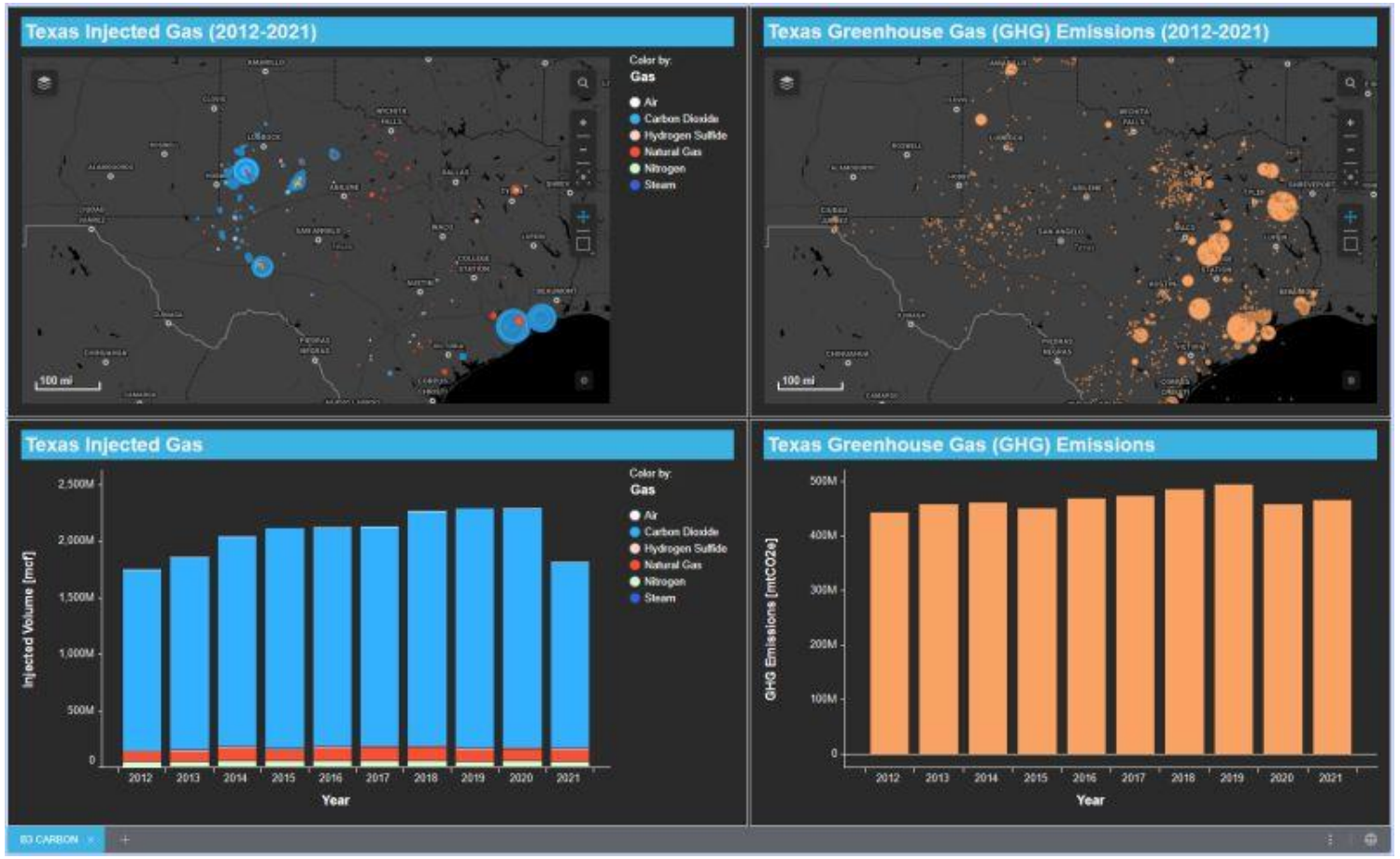
Ethanol Plant

Cement Plant



Cost of Capturing CO_2 from Industrial Sources, January 10, 2014, DOE/NETL-2013/1602

Over the past decade, **19 TCF (nearly 1 Gt) of carbon dioxide** was injected into subsurface formations throughout **Texas**.



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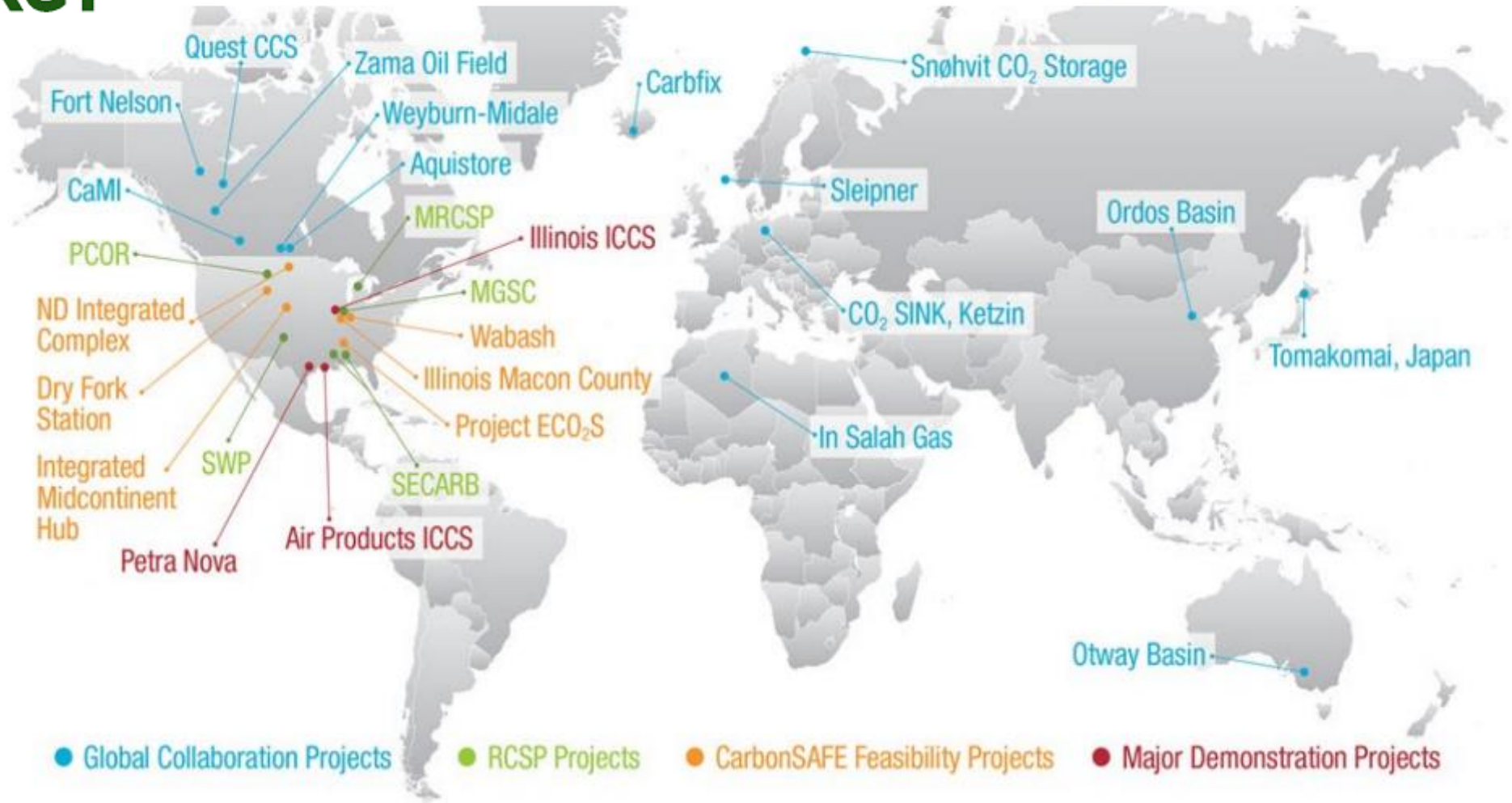
We have already ‘done’ a lot of CCS!

U.S. DEPARTMENT OF ENERGY

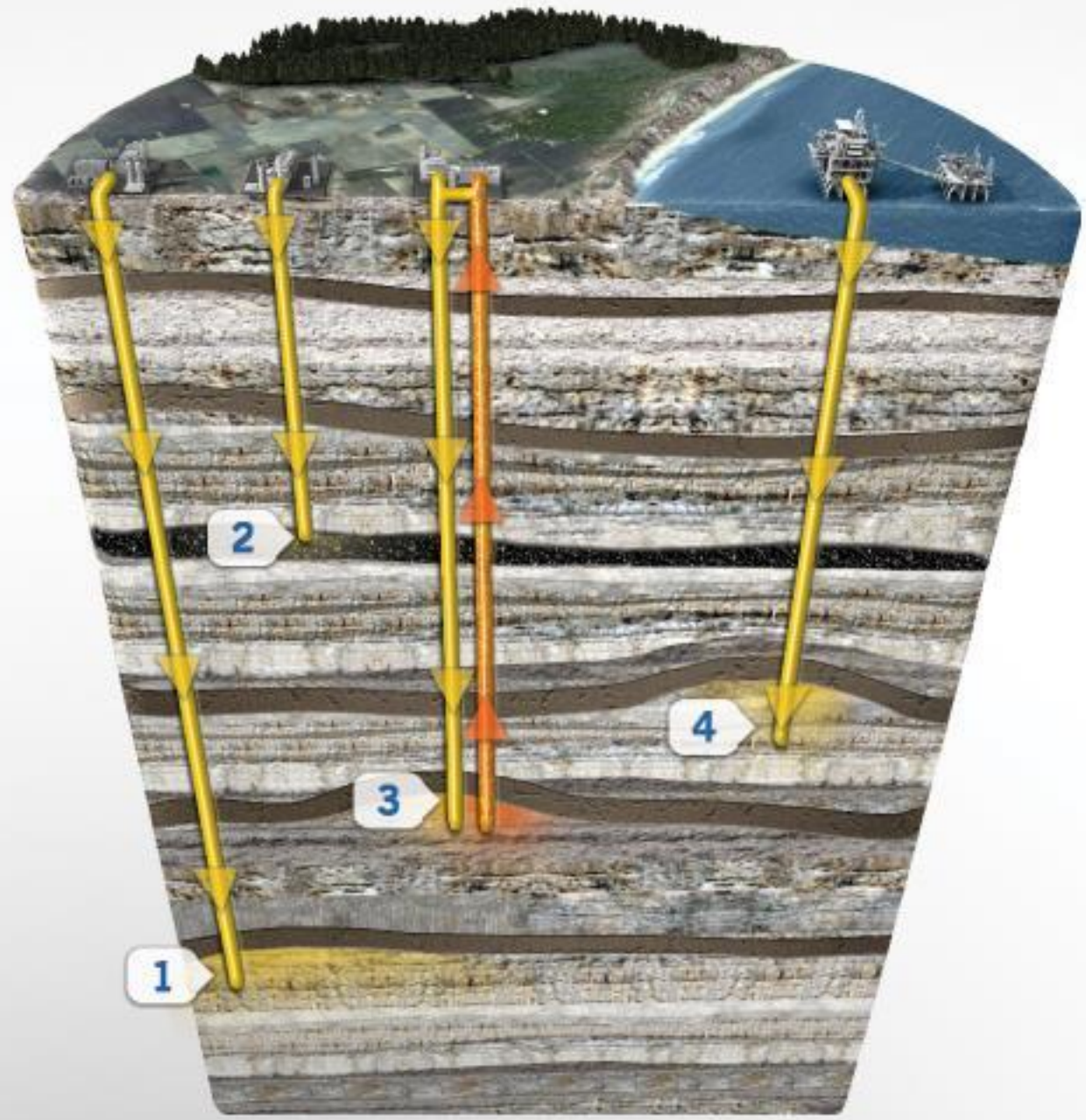
Exhibit 2-2. Map depicting locations of major U.S. DOE/NETL projects and global collaborations



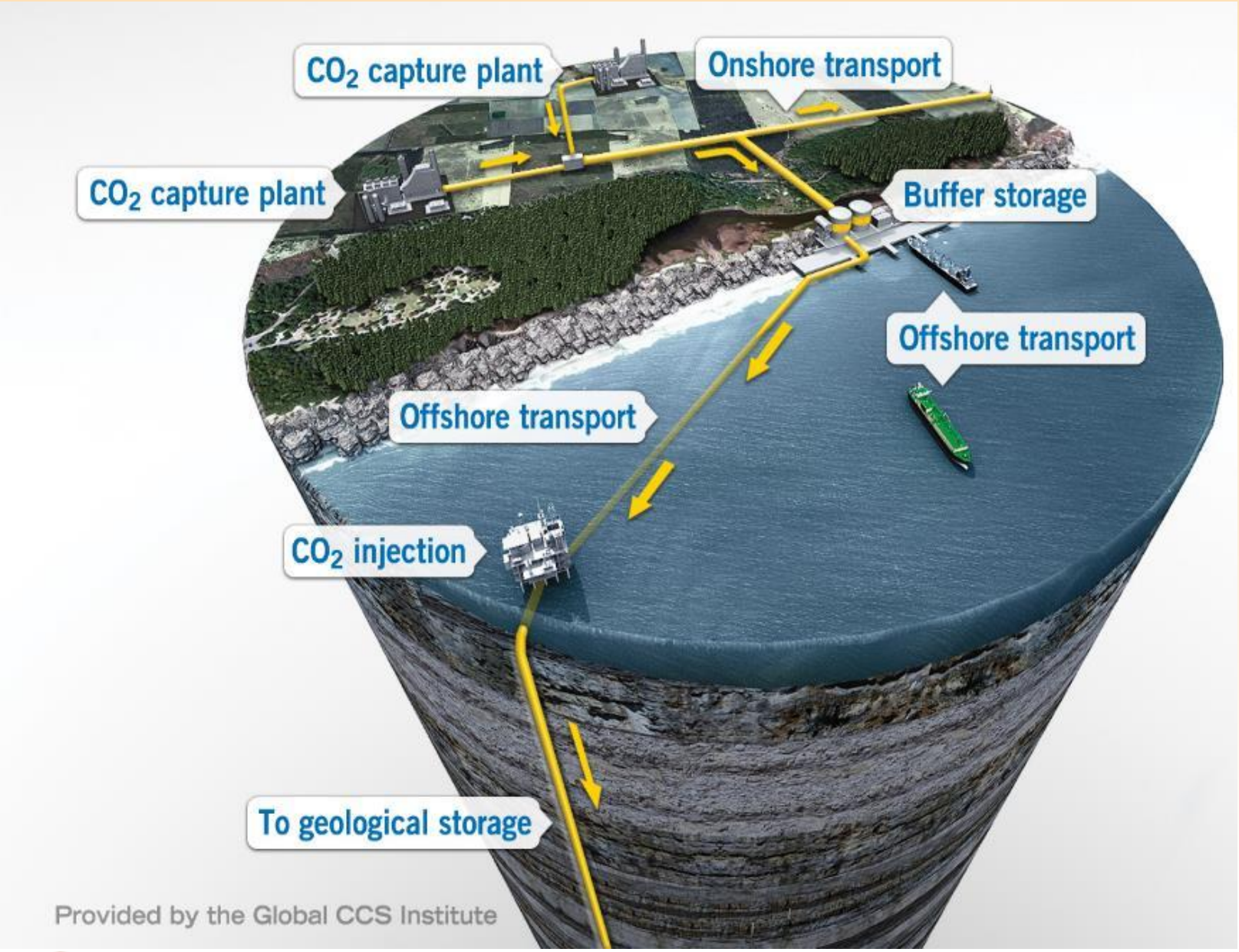
STORAGE OVERVIEW

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

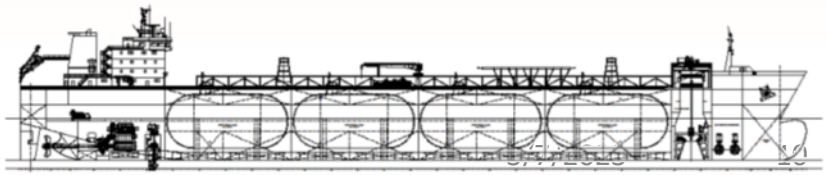


Provided by the Global CCS Institute

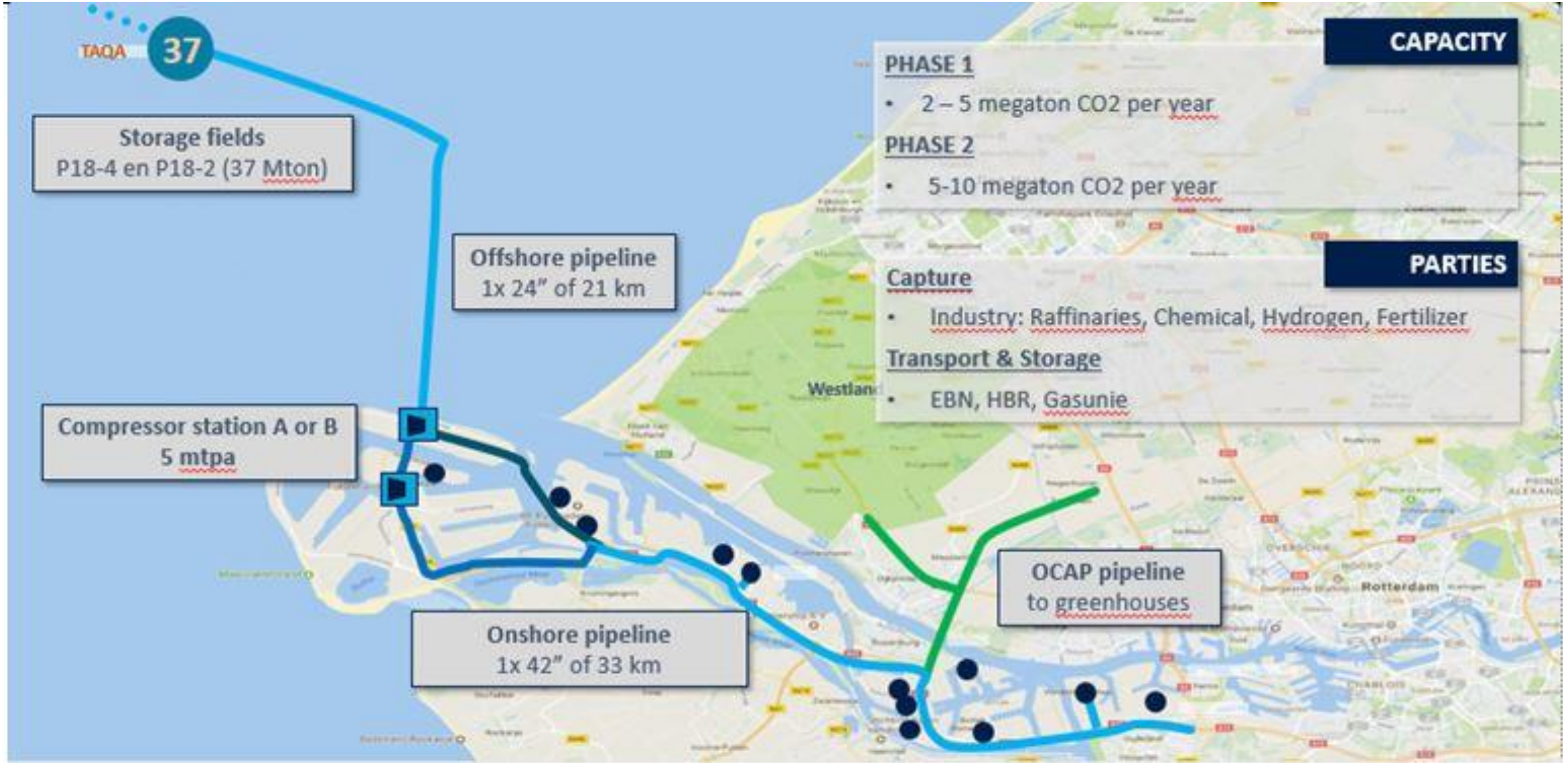


Why Offshore?

- **Emissions hubs are at coast/ports**
- **Single land/mineral owner (GLO)**
- **Avoid NUMBY/Unitization**
- **Data availability**
- **Fewer, younger legacy wells**
- **Avoid USDW – Class VI focus**
- **Monitoring easier?**
- **Long term liability – GLO**
- **Vessel transport flexibility**



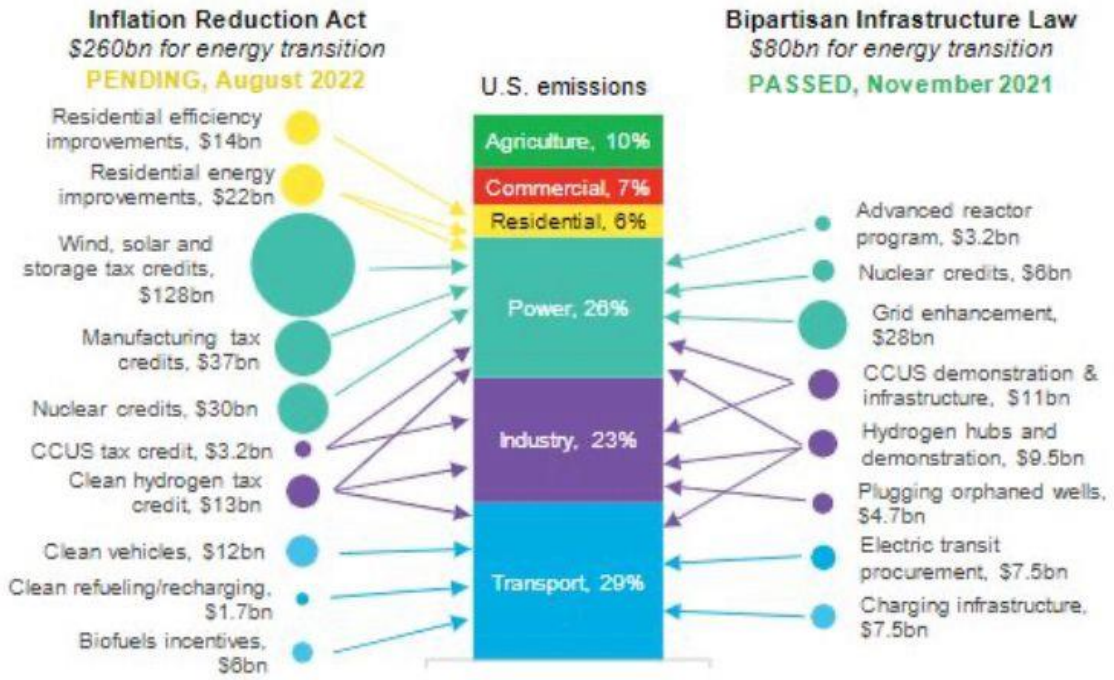
PORTHOS PROJECT - NETHERLANDS



Inflation Reduction Act of 2022 (IRA)

- All carrots (credits), no sticks (taxes)
- Extremely broad, most focus is on EVs, renewables, and power, etc.
- CCS is very significant, but not the main element by far.
- Manchin (D-WV) wanted pipelines.
- Sinema (D-AZ) wanted carried interest continued.

Figure 1: Estimated 2022-31 energy transition spending in Inflation Reduction Act and Bipartisan Infrastructure Law



Source: EIA, EPA, Joint Committee on Taxation, BloombergNEF. Note: Chart only captures tax credits and incentives, not grant programs or loans. Bn is billion. CCUS is carbon capture, utilization and storage.

	Existing 45Q	IRA 45Q
CCUS Baseline Amount	$50—for sequestration $35—for EOR or utilization	$17—for sequestration $12—for EOR or utilization
CCUS Bonus Amount (if prevailing wage, hour, and apprenticeship requirements are met)	No bonus	$85—for sequestration $60—for EOR or utilization
DAC Baseline Amount	$50—for sequestration $35—for EOR or utilization	$36—for sequestration $26—for EOR or utilization
DAC Bonus Amount (if prevailing wage, hour, and apprenticeship requirements are met)	No bonus	$180—for sequestration $130—for EOR or utilization

The baseline amounts, however, may be multiplied by five if the qualifying facility meets certain wage, hour, and apprenticeship requirements.

$85/ton CO2 x 1 Mt/yt = $85M/yr

X 12 years = $1B total credit value

Credit can receive:

- **Direct Pay option**
- **Transferrable**

REGIONAL CARBON CAPTURE DEPLOYMENT INITIATIVE

JOBS AND ECONOMIC IMPACT OF CARBON CAPTURE DEPLOYMENT
Texas

TOTAL JOBS POTENTIAL

Project Jobs	Operations Jobs	Infrastructure Jobs
15,010	9,230	3,340

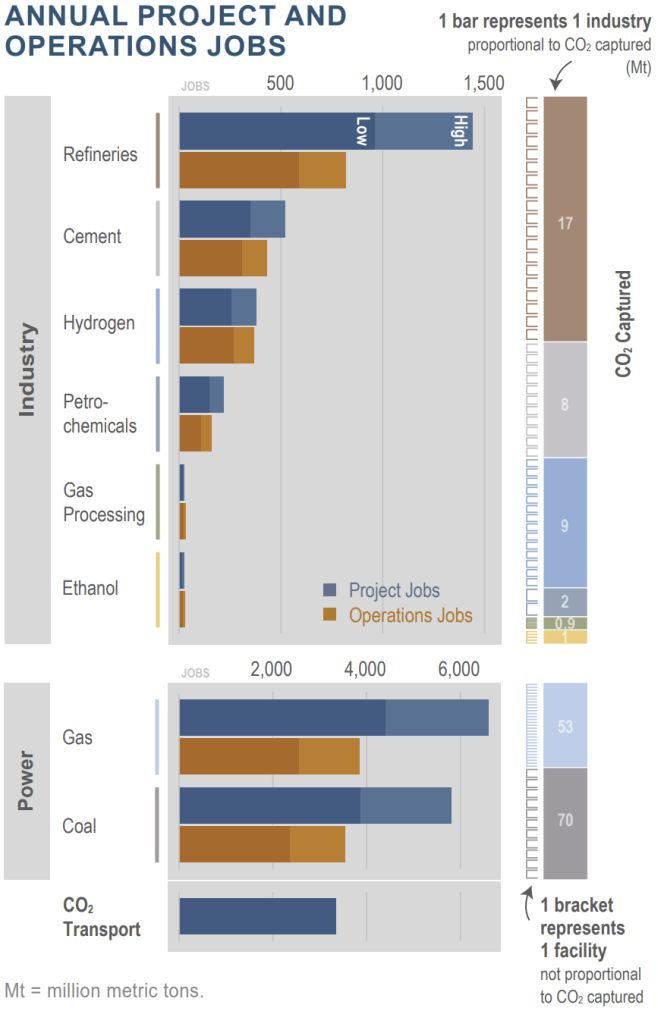
Texas has the opportunity to create an annual average of up to **18,350 project jobs** over a 15-year period and **9,230 ongoing operations jobs** through the deployment of carbon capture at 95 industrial and power facilities. The retrofit of equipment at these facilities has the potential to capture nearly **161 million metric tons** of carbon dioxide (CO_2) per year. Along with the development of CO_2 transport infrastructure, this would generate up to **$59.9 billion** in private investment.

CREATING JOBS & CAPTURING CARBON

Carbon capture is essential to meeting mid-century emissions reduction goals while retaining and growing a domestic base of high-wage energy, industrial, and manufacturing jobs. Carbon capture retrofits require facilities to be outfitted with capture technologies such as amine scrubbers to remove CO_2 from exhaust gas and compressors to make the CO_2 transport-ready, that are dependent upon the type of industrial plant and vary across industries and facilities. There are jobs associated with the equipment, materials (e.g., cement and steel), engineering, and labor required to install the capture technology, as well as ongoing jobs to operate and maintain the retrofits. These are referred to as **project jobs** and **operations jobs**.

Rhodium Group performed an economic analysis based on the Regional Carbon Capture Deployment Initiative's near- and medium-term capture potential scenario.[1] The Rhodium analysis quantifies the economic impact and employment opportunities of carbon capture retrofit projects by deploying state-specific data in the IMPLAN economic model. The analytical results measure the impact of project investment and operation costs through expected annual jobs. Average annual project jobs were calculated assuming deployment of all projects within the 15-year period from 2021-2035. The jobs reported are in-state jobs, directly associated with carbon capture retrofits. They do not include other jobs at the facilities, nor indirect and induced jobs.

ANNUAL PROJECT AND OPERATIONS JOBS



Mt = million metric tons.

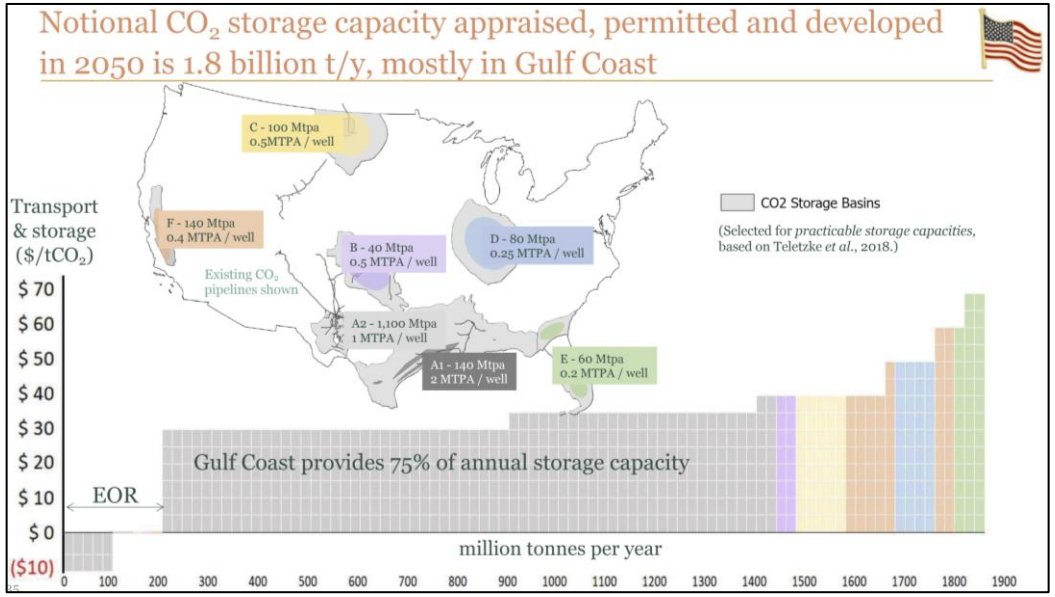
This figure depicts the low and high range of estimated annual average project jobs, transport infrastructure jobs, and ongoing operations jobs that could be created through carbon capture retrofits at industrial and power facilities in Texas. The potential amount of CO_2 captured and the number of potential near- or medium-term capture facilities in each industry are shown on the right.

https://rhg.com/research/state-ccs/

PRINCETON UNIVERSITY | andlinger center for energy + the environment | High Meadows Environmental Institute | Carbon Mitigation Initiative

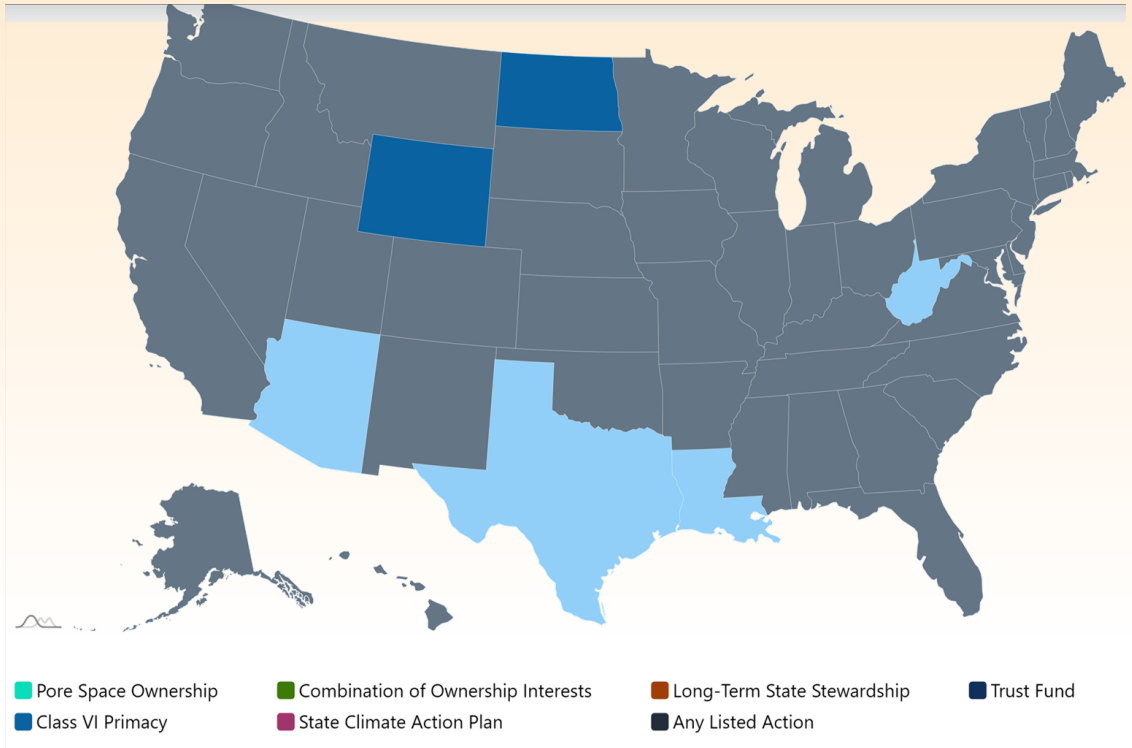
Interim Report

Net-Zero America: Potential Pathways, Infrastructure, and Impacts

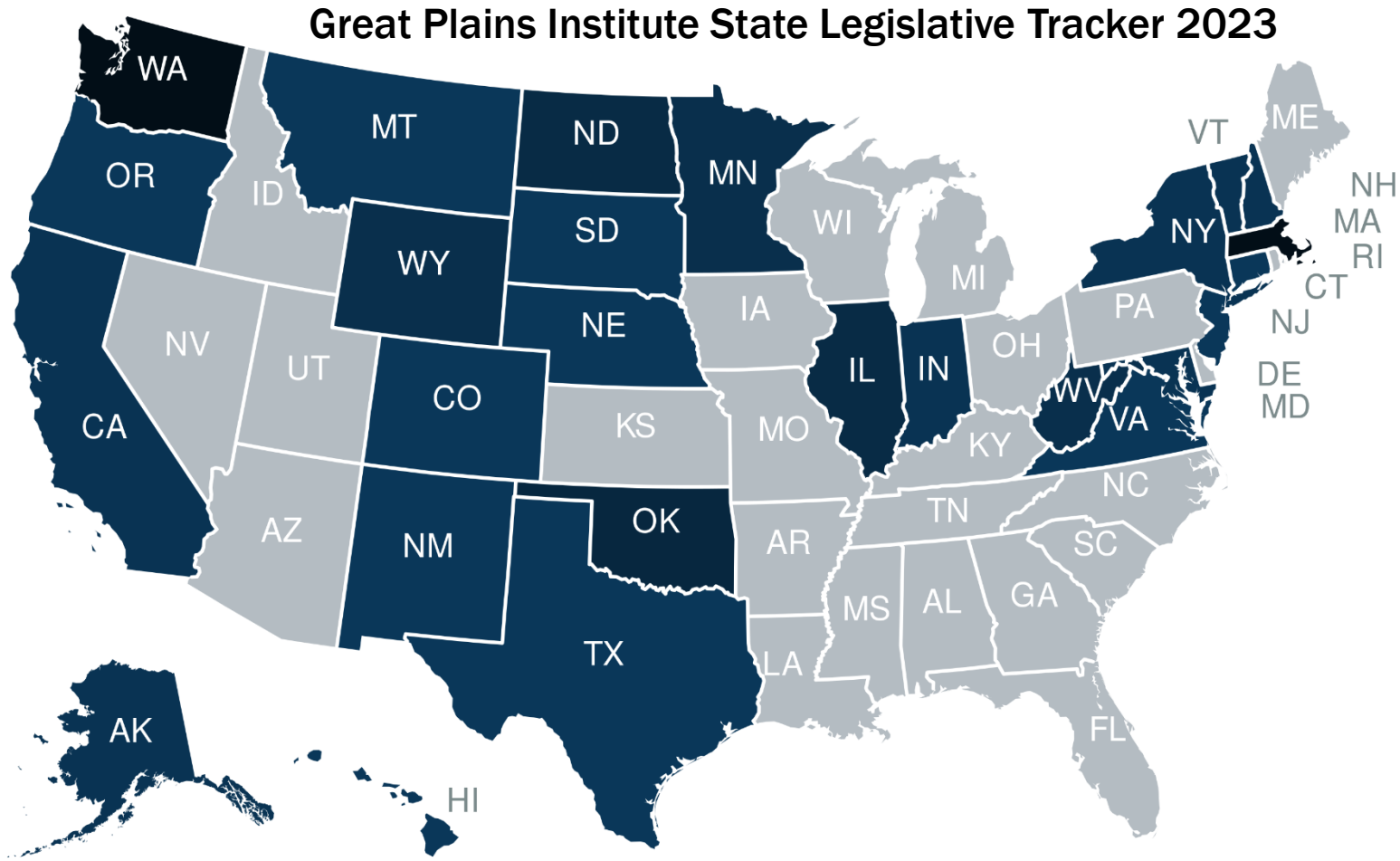


Injection Well Permitting

- EPA Class II – CO2 used for enhanced oil recovery (EOR).
- EPA Class VI – CO2 injected for storage/disposal.
- State Primacy



State legislative sessions are underway in 2023 in most states across the country and **more than 70 carbon management, hydrogen, and procurement-related measures and bills** of interest are under consideration.



https://cdrlaw.org/ccus-tracker/

SUMMARY

- Carbon Capture Utilzation and Storage (CCUS) is not a new topic.
- CCUS basics: Capture, Transport, Storage.
- Deployment focus is on emission hubs, including marine ports.
- Economics are rooted in tax credits

- CCUS is an economic growth opportunity.

RESOURCES

- DOE-NETL CCS Newsletter: https://listserv.netl.doe.gov/scripts/wa.exe?SUBED1=SEQUESTRATION&A=1
- GCCSI: https://www.globalccsinstitute.com/
- Gulf Coast Carbon Center: https://www.beg.utexas.edu/gccc/

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US Department of Energy - NETL

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Liquefied CO_2 (LCO_2) Shipping

Topics of interest: rapidly evolving full-chain maritime solutions for low-C energy development and use.

- Capture of emissions from powering vessels
- Transport of low carbon energy (carbon-neutral hydrocarbons, Hydrogen, Ammonia)
- LCO_2 transport; synergy with LPG/LNG transport and design
- Leapfrogging into offshore storage without pipelines – FPSO/FSO for CCS, injection capabilities
- Onshore buffer storage capacity aspects

Northern Lights JV awarded contracts for building of two dedicated CO_2 carriers to Dalian Shipbuilding Industry Co., Ltd. Transocean was selected to drill the carbon injection well and a second sidetrack well for the project.

CCUS State Legislative Tracker -

cdrlaw.org/ccus-tracker/

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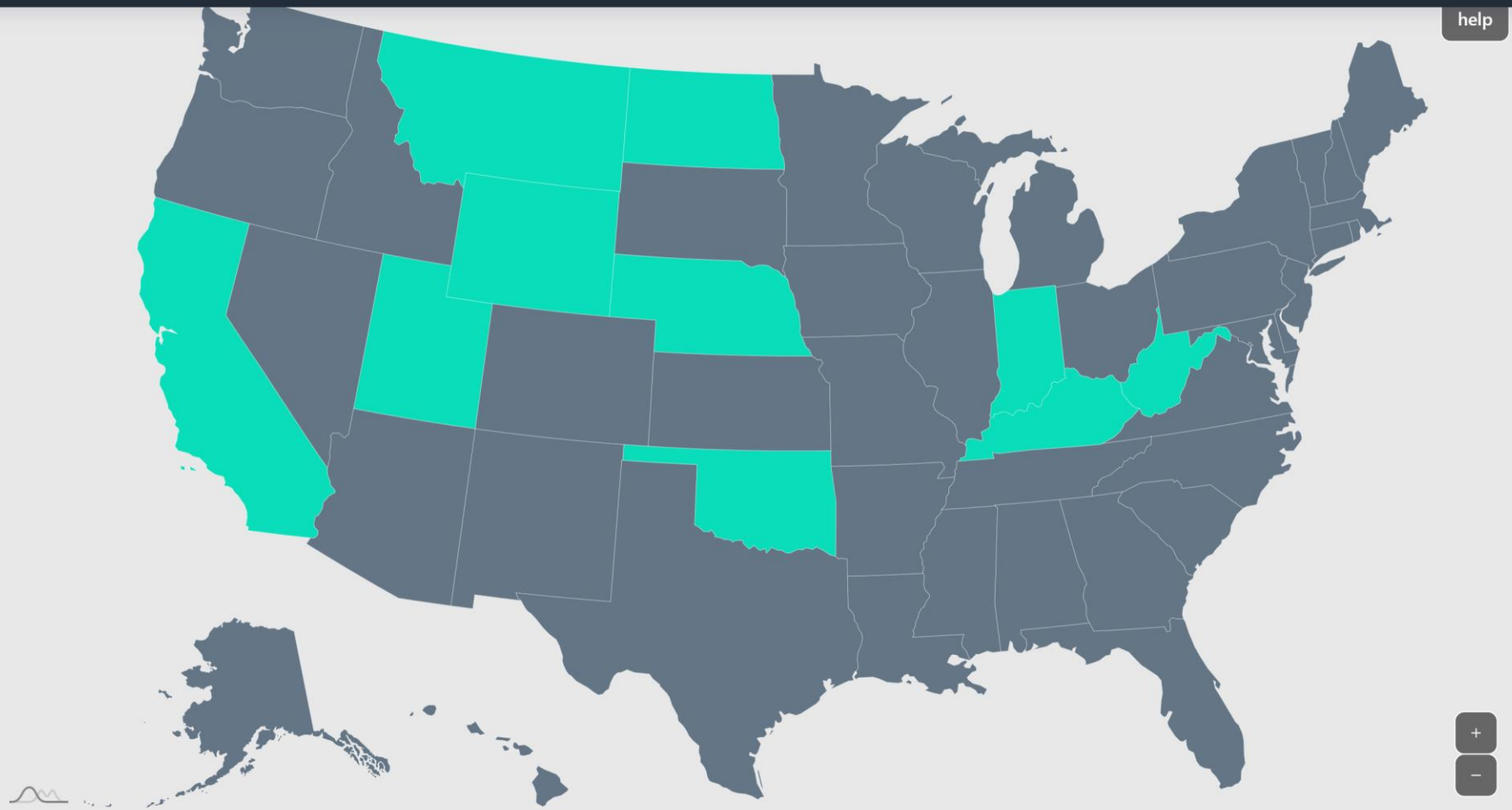

- Pore Space Ownership
- Combination of Ownership Interests
- Long-Term State Stewardship
- Trust Fund
- Class VI Primacy
- State Climate Action Plan
- Any Listed Action

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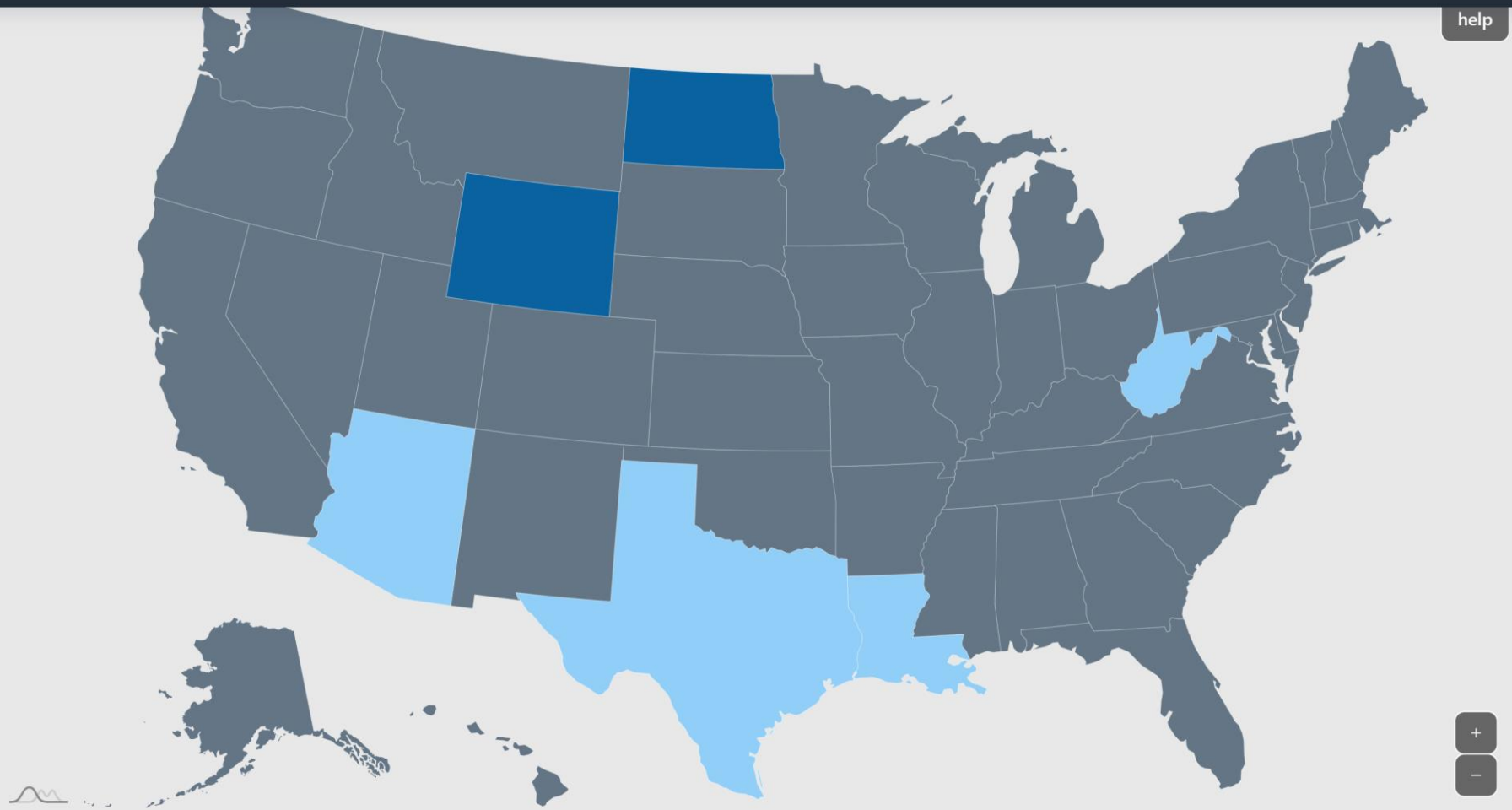

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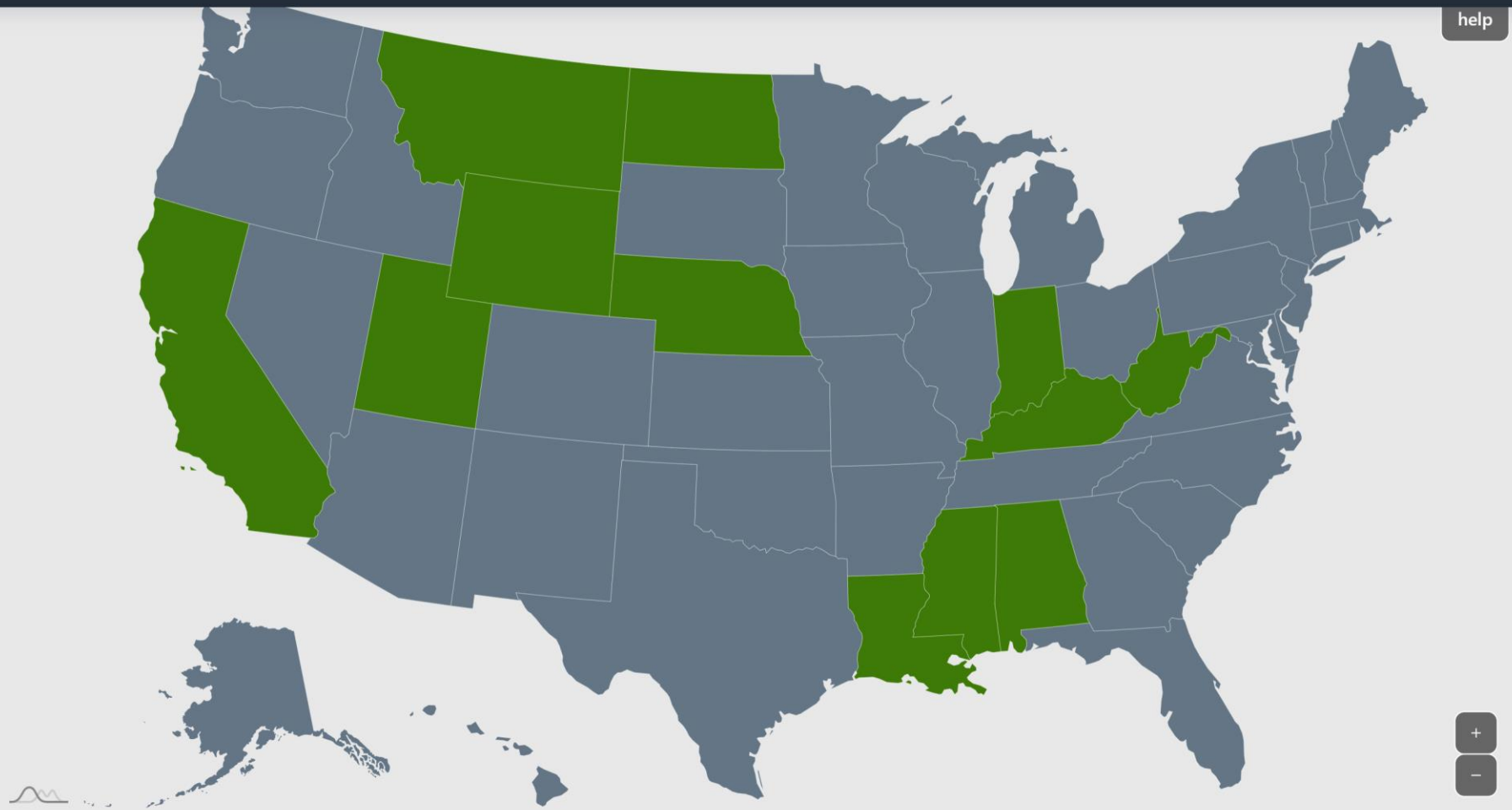

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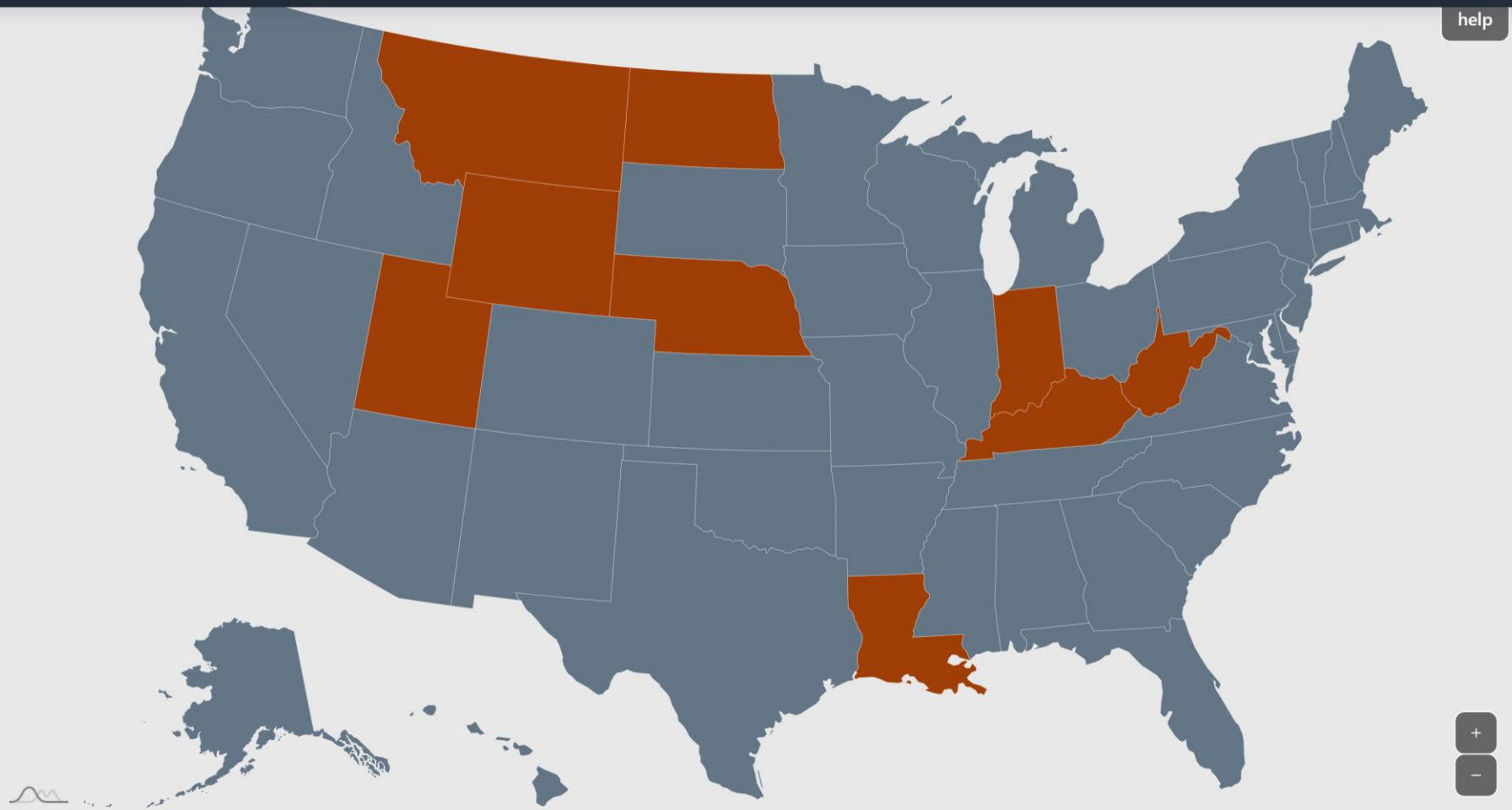

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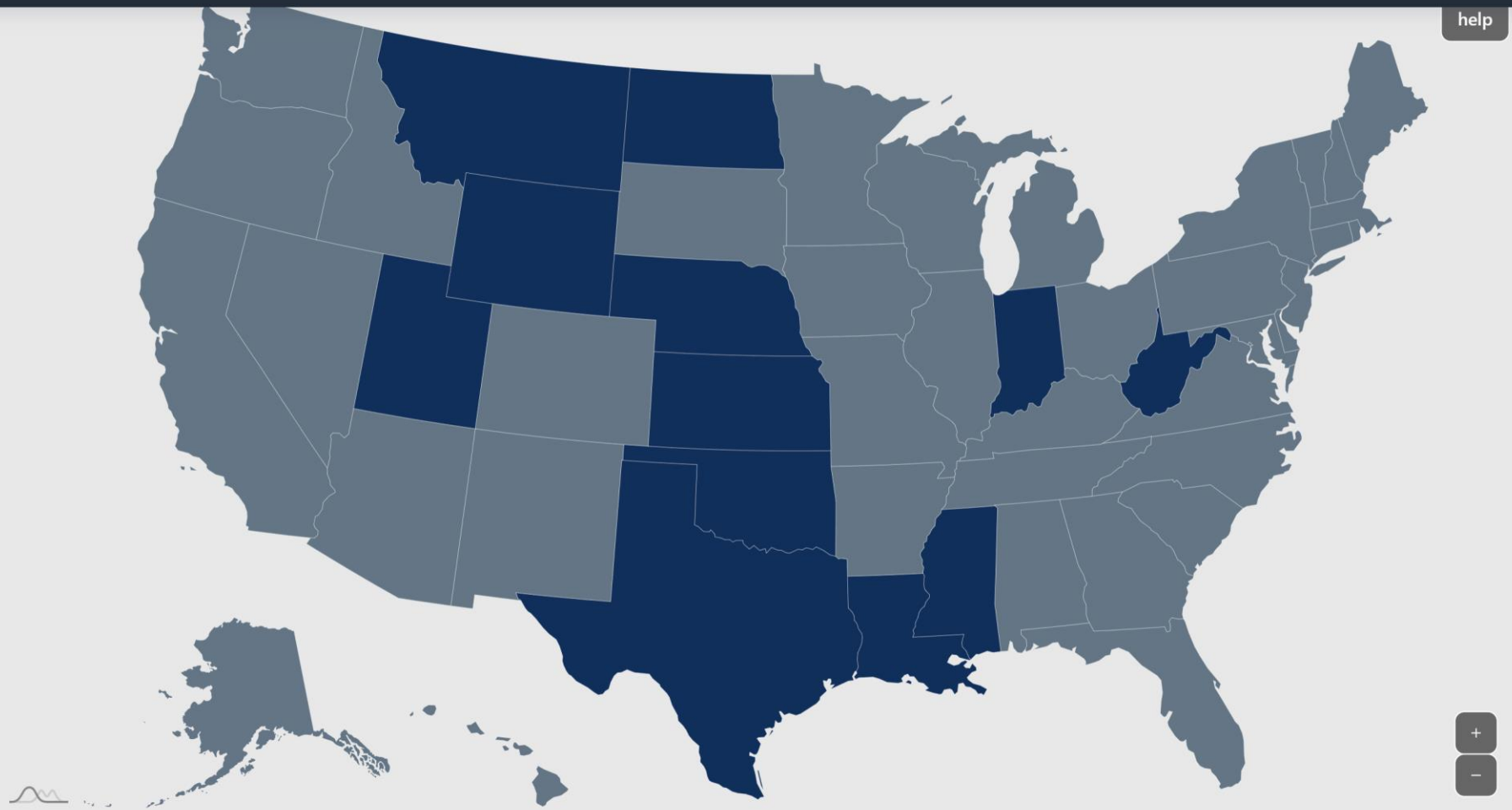

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