



U.S. DEPARTMENT OF
ENERGY

Fossil Energy and
Carbon Management

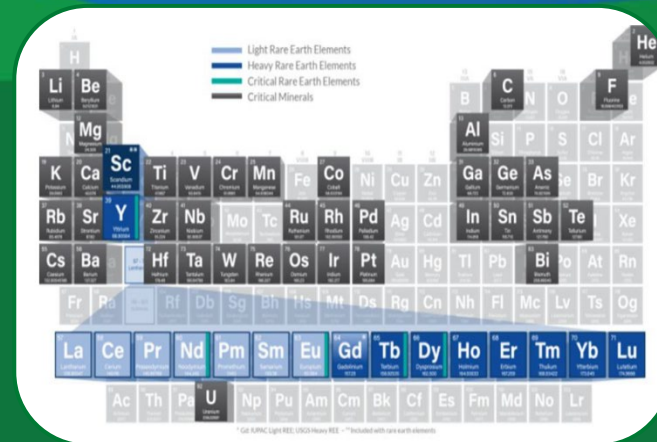
CO₂ Research Center

The Role of Carbon Capture in Meeting Net-Zero Carbon Goals

Dr. Jennifer Wilcox

PRINCIPAL DEPUTY ASSISTANT SECRETARY
FOSSIL ENERGY AND CARBON MANAGEMENT

September 14, 2022



Fossil Energy and Carbon Management (FECM)

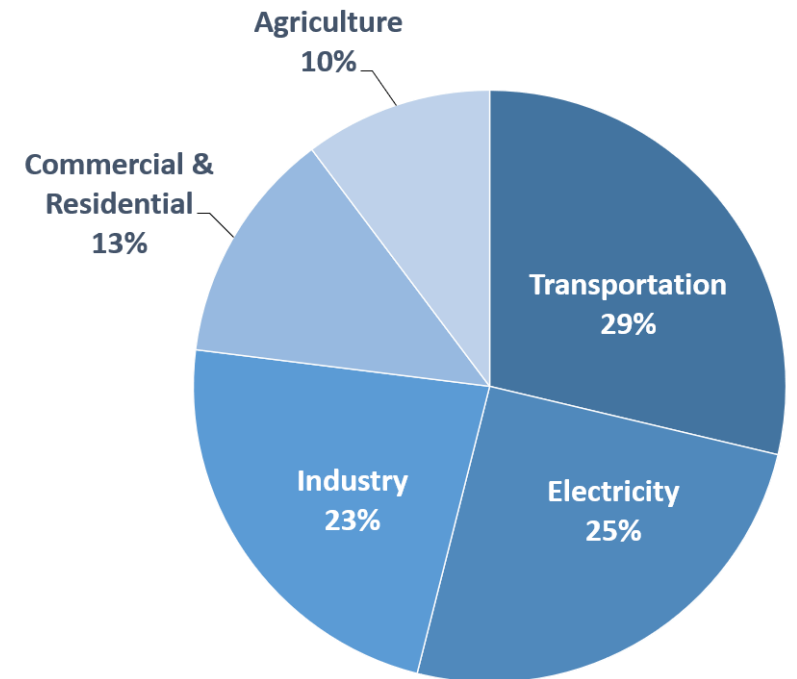
Office of Fossil Energy and Carbon Management

DOE-FE is now DOE-FECM

New name for our office reflects our new vision

- President Biden's goals:
 - 50% emissions reduction by 2030
 - CO₂ emissions-free power sector by 2035
 - Net zero emissions economy by no later than 2050

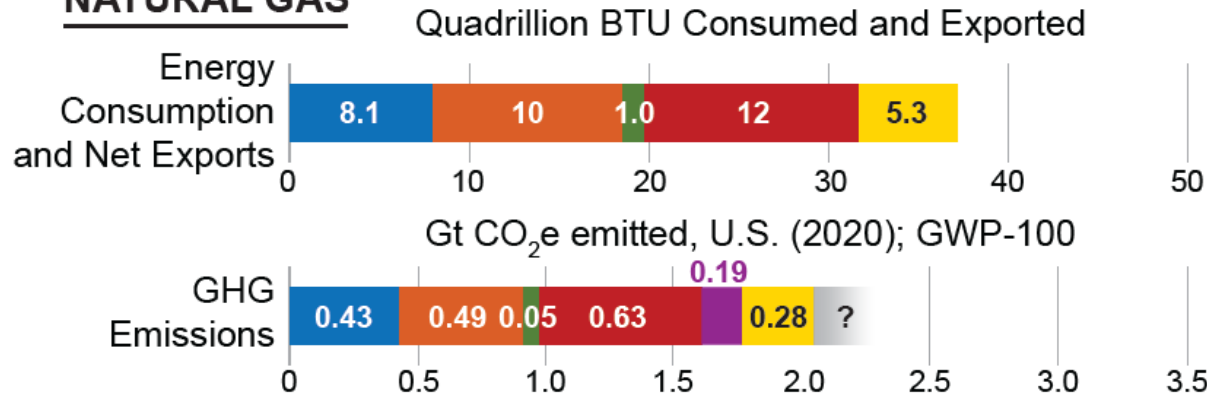
Total U.S. Greenhouse Gas Emissions
by Economic Sector in 2019



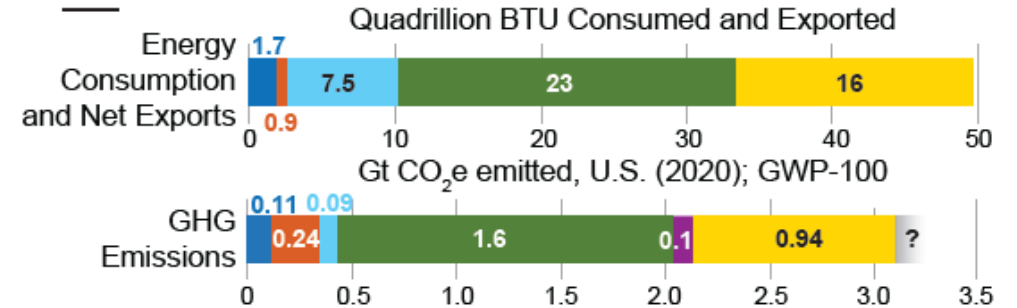
U.S. Environmental Protection Agency (2021). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019

Fossil Energy and Role of Carbon Management

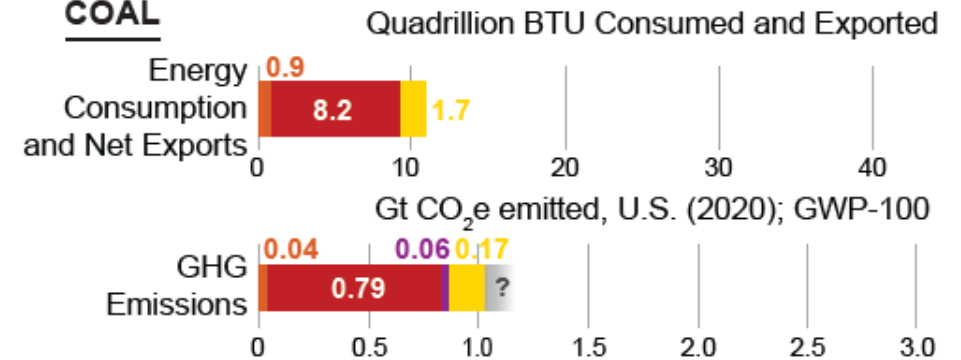
NATURAL GAS



OIL



COAL



■ Heat (commercial, residential)
 ■ Heat (industrial)
 ■ Industry (non-heat)
 ■ Transportation
 ■ Electric Power
■ Supply Chain
 ■ Exports
■ Additional unknown supply chain emissions associated with coal, natural gas and oil production. Both quantification and mitigation of these emissions is an FECM priority.

FECM Strategic Vision

Advancing Carbon Management Approaches Toward Deep Decarbonization

Priorities: Point-source carbon capture, carbon dioxide conversion, carbon dioxide removal (CDR), and reliable carbon transport and storage

Advancing Technologies that Lead to Sustainable Energy Resources

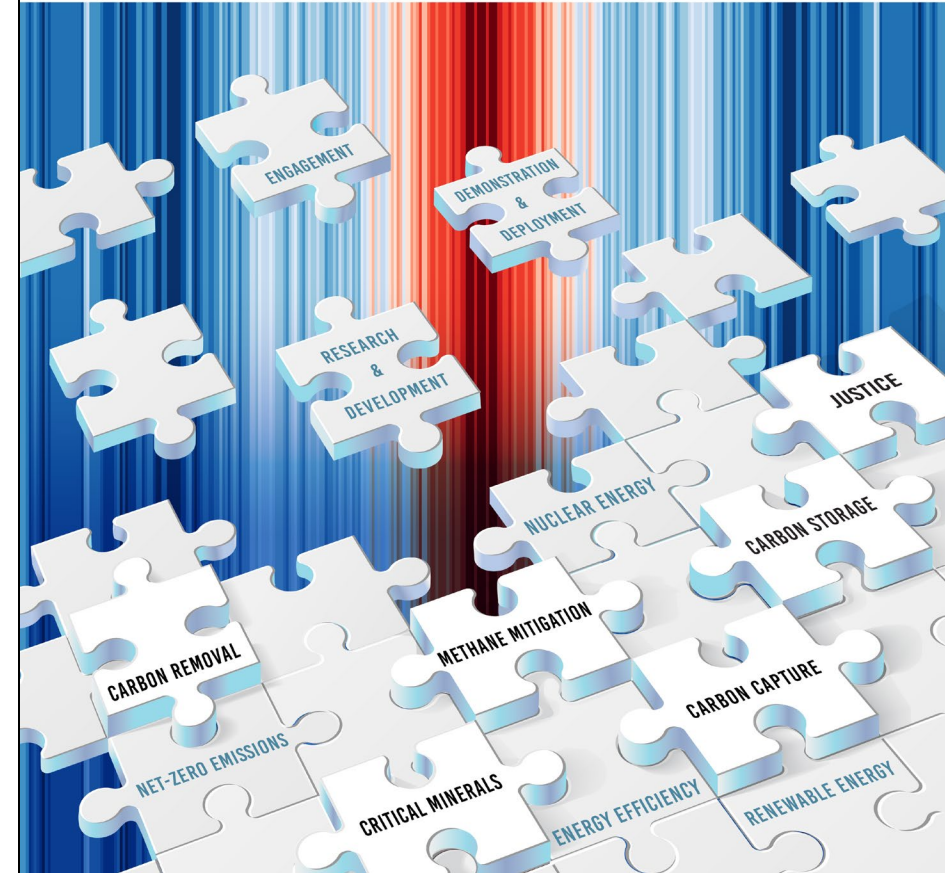
Priorities: Hydrogen with carbon management, domestic critical minerals (CMs) production, and methane mitigation

Advancing Justice, Labor, and Engagement

Priorities: Justice, labor, and international and domestic partnerships

STRATEGIC VISION

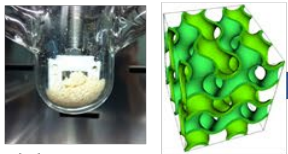
The Role of Fossil Energy and Carbon Management in Achieving Net-Zero Greenhouse Gas Emissions



Point Source Capture Program

Integrated Approach to Accelerate Technology Development

Lab & Bench



TRL 2-4

Small Pilots



TRL 4-5

Large Pilots



TRL 5-7

FEED Studies

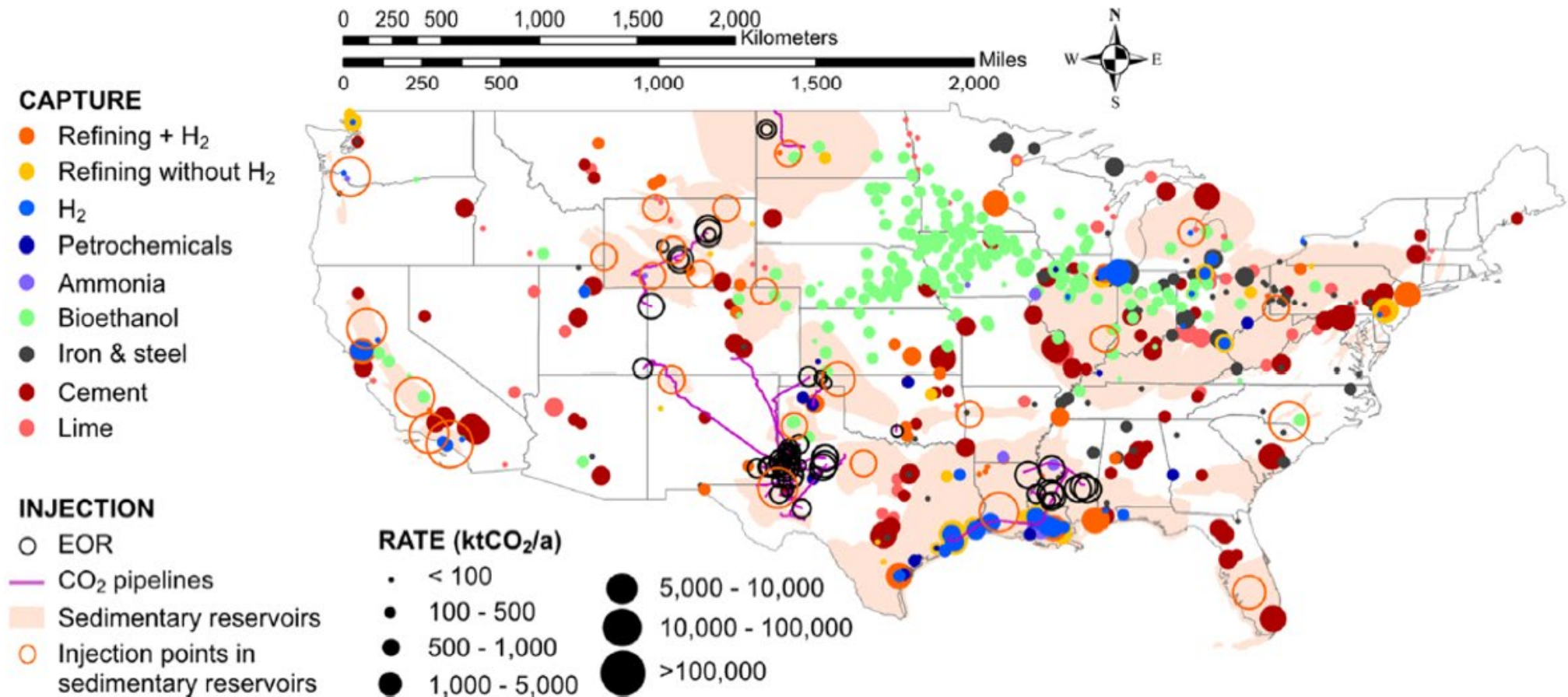


Point Source Capture Focus

- Develop capture technologies for the power and industrial sectors
- Reduce CAPEX/OPEX under a wide range of feed conditions
- Achieve high capture efficiencies (>95%)
- Maximize co-benefit pollutant removal
- Engineering-based Simulation (CCSI²)
- Create low-carbon supply chains (i.e., cement, steel, hydrogen, etc.)

Industrial Sectors

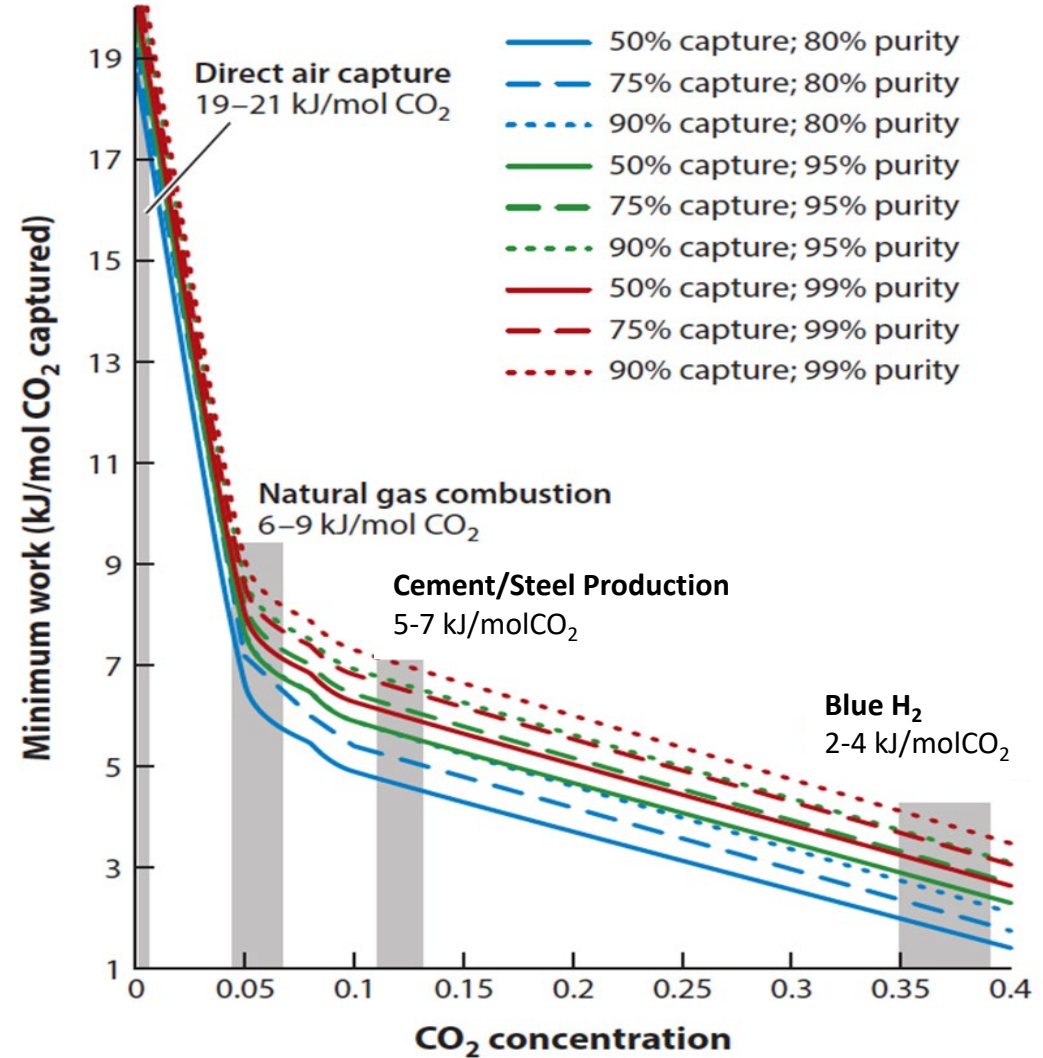
- CCS has the potential to significantly reduce some industrial sectors, which are hard to decarbonize today
- Stacking 45Q and CA's LCFS is leading to increased activity in this space – bioethanol, in particular



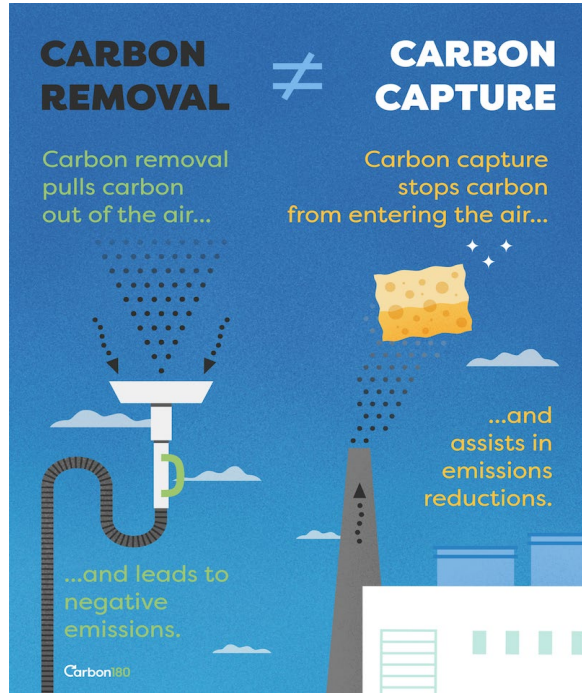
CCS and CDR Need to Be Done In Parallel

TABLE 2.9.1 Scale, Energy, Cost, and Example Carbon Capture Projects Globally

Capture Application	2020-Scale (MtCO ₂ /yr) ^a	Percent CO ₂ ^b	Min Work (kJ/mol) ^c	Nth-kind Cost ^d (\$/tCO ₂)	Example Projects (Start Date; Scale)
Natural Gas	700	3–5	~9–10	~55–60	Elk Hills, Fluor (2020; Mt/yr)
Industry (process emissions only)					
Cement	67	25–30	~4	~30	Lafarge Holcim, Total, Svante (2019; kt/yr)
Refining	40	15–20	~6	~40	Norway, Statoil Mongstad (2012; 100s kt/yr)
Bioethanol	37	99+	~0	~<20	Decator, ADM (2017; Mt/yr)
Hydrogen	26	45–70	~2–3	~25–30	Port Arthur, Air Products (2013; Mt/yr)
Iron and Steel	19	20–25	~5	~35–40	Abu Dhabi CCS Project, UAE (2016; Mt/yr)
Air Capture ^e					
Solvents	~1	0.04	21	~150–600	Carbon Engineering (2023; 1 Mt/yr)
Solid Sorbents	<1	0.04	21	~150–600	Climeworks—14 plants globally (kt/yr)



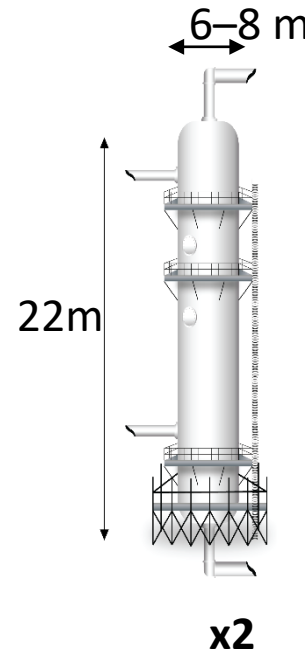
Distinction Between Point-Source Capture and Carbon Dioxide Removal



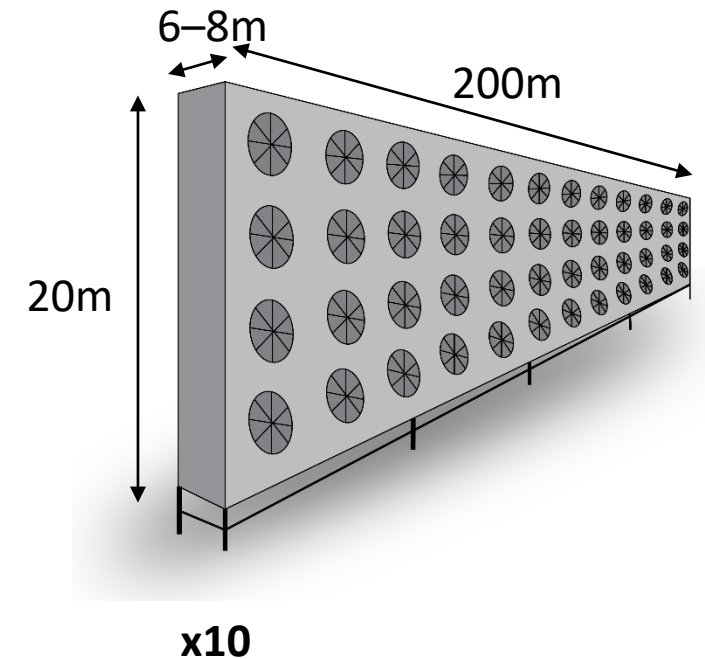
Source: <https://grist.org/wp-content/uploads/2021/12/carbon180-carbon-removal-is-not-carbon-capture.png>

Different designs and various technologies lead to different impacts, energy, land, and water requirements

Power Plant
MEA Scrubber



DAC Contactor



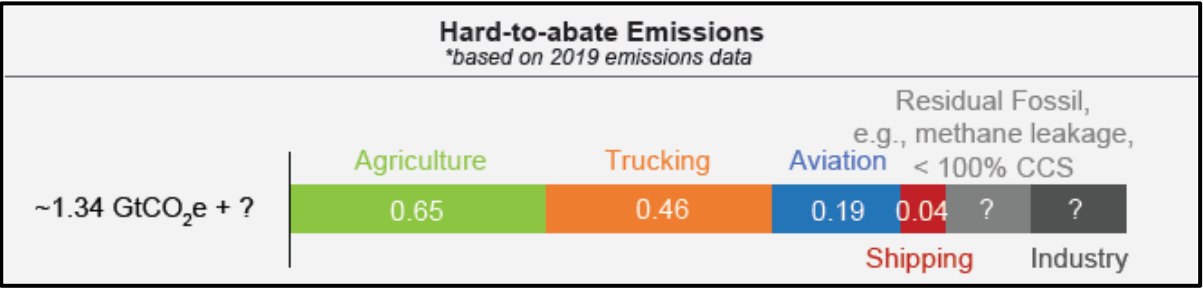
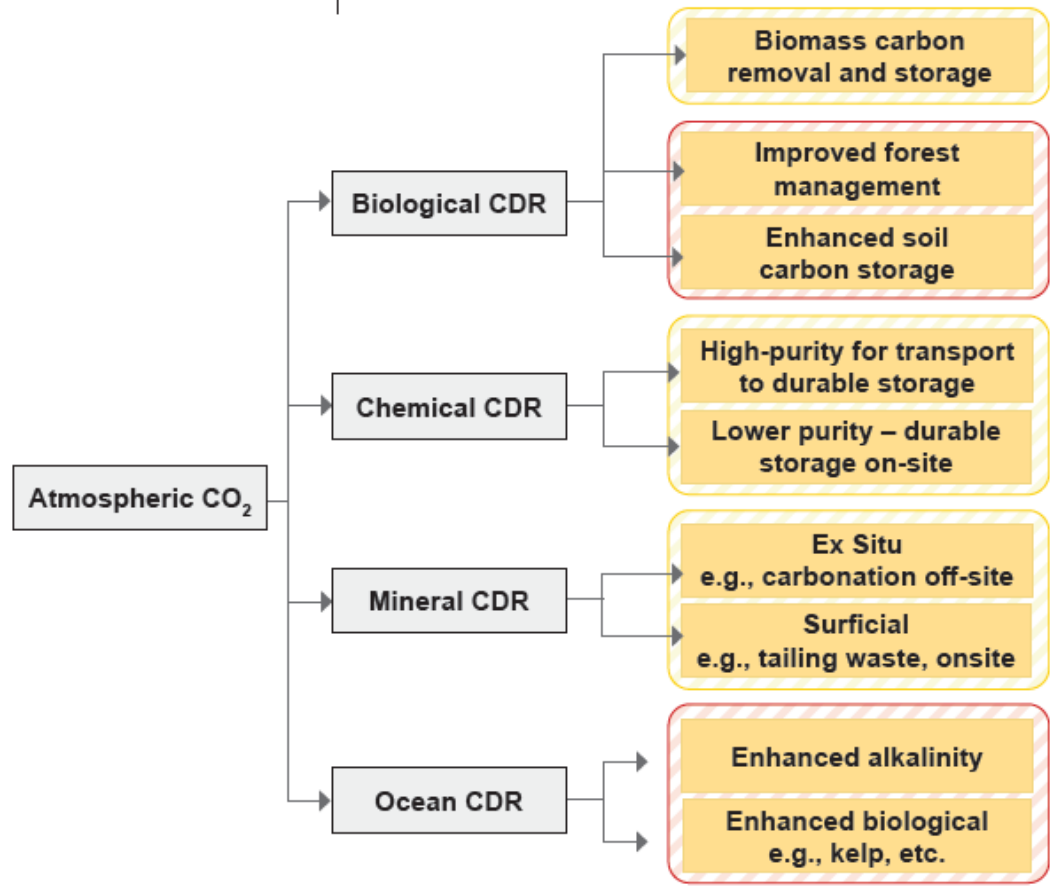
U.S. DEPARTMENT OF
ENERGY

Fossil Energy and
Carbon Management

CDR Pathways and Hard-to-Abate Emissions

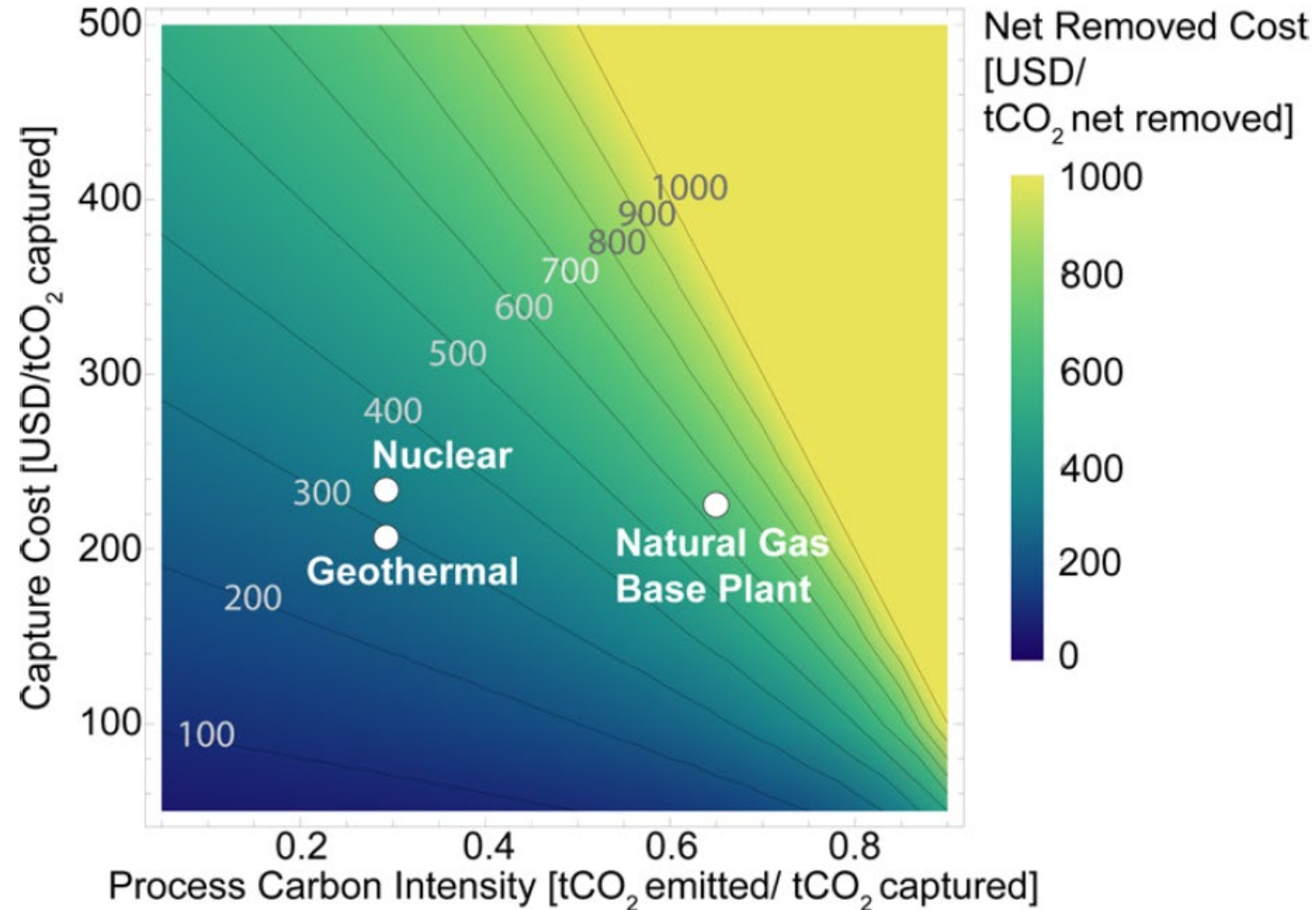
■ Strategic Vision Directions
■ DOE Cross-cuts

■ TRL 6-7 (small or few demos)
■ TRL 3-4



Reference: FECM Strategic Vision (April 2022)

Leveraging Low-Carbon Utilities Can Reduce CAPEX



Recent FECM Awards Focus on Coupling DAC to Clean Heat

- As a leader in advancing carbon management technologies, FECM is **researching and investing in DAC technologies** to help scale them up for the commercial market
- DAC coupled to durable storage for carbon dioxide removal is **energy intensive, relying on both heat and electricity inputs**
- FECM recently awarded **\$11 million** (federal) for 4 FEED studies leveraging existing sources of clean heat for DAC – nuclear, geothermal, and industrial waste heat



DAC coupled to nuclear heat: \$3.4m (\$2.5m federal) FEED study led by Battelle with AirCapture, Carbonvert, Sargent & Lundy, Southern Company, and the University of Alabama to be located at Southern Company's Joseph M. Farley nuclear power plant in Columbia, AL. Image:

[NRC](#)



DAC coupled to nuclear heat and power: \$3.1m (\$2.5m federal) FEED study led by Exelon with Carbon Engineering, Worley Group, 1PointFive, Univ. of Illinois, and PNNL to be located at Exelon's Byron Generating Station for 250k net tons CO₂/year captured with permanent storage. Image: [CE](#)



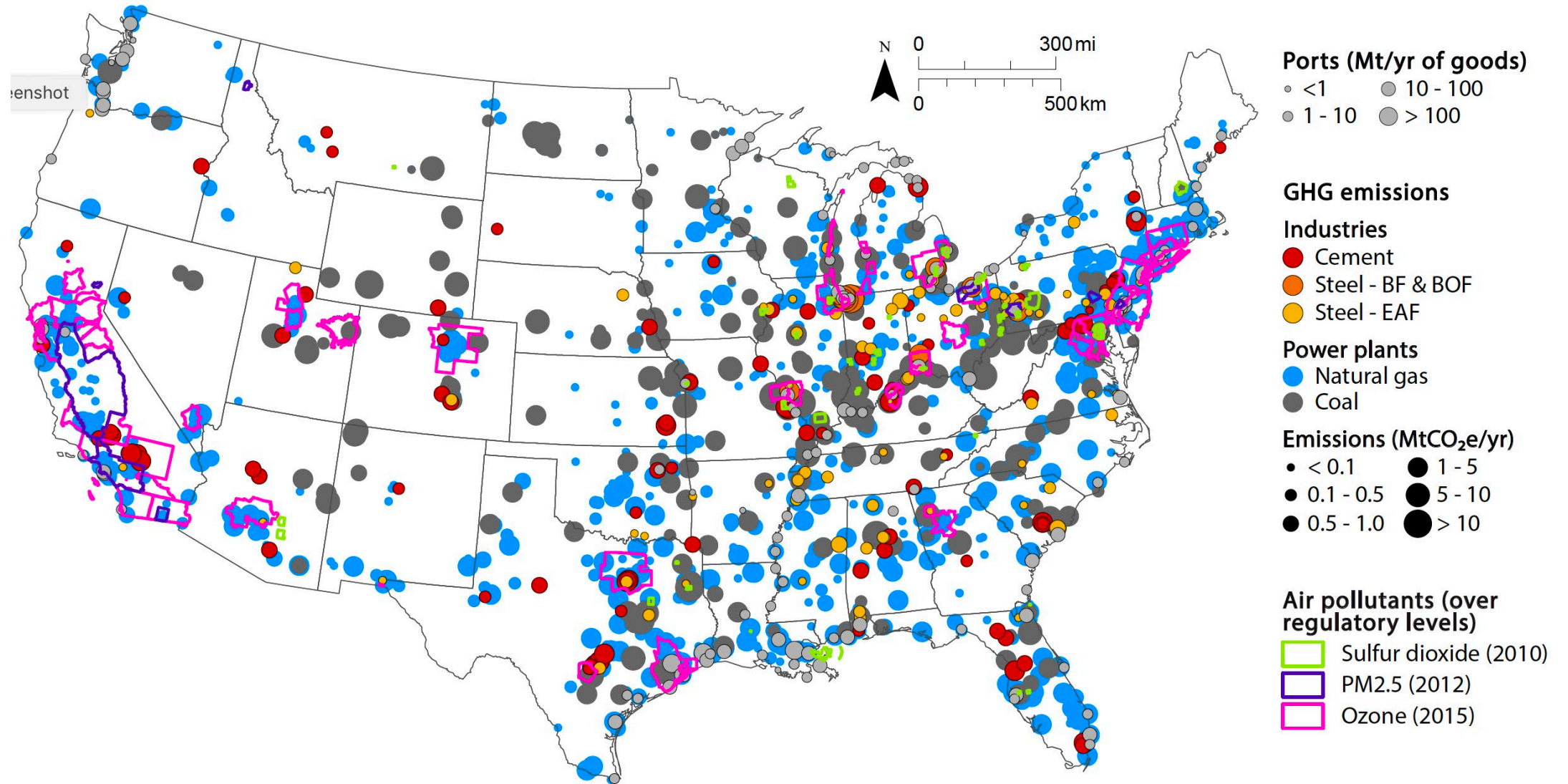
DAC coupled to geothermal energy: \$3.1m (\$2.5 federal) FEED study led by UIUC with Climeworks, Ormat, Sentinel Peak, Visage Energy, LLNL, and Kiewit to be located at an Ormat geothermal facility in California. Image: [Ormat](#)



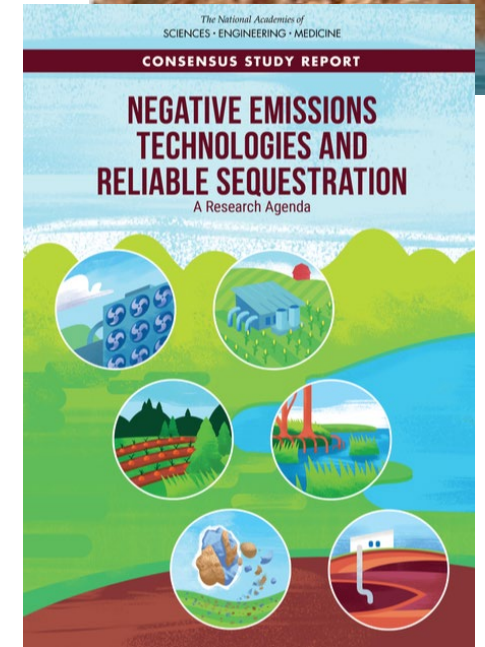
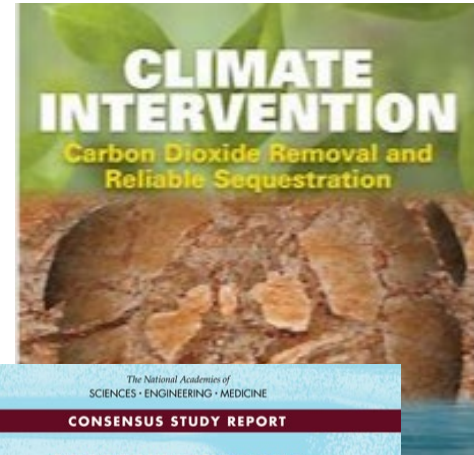
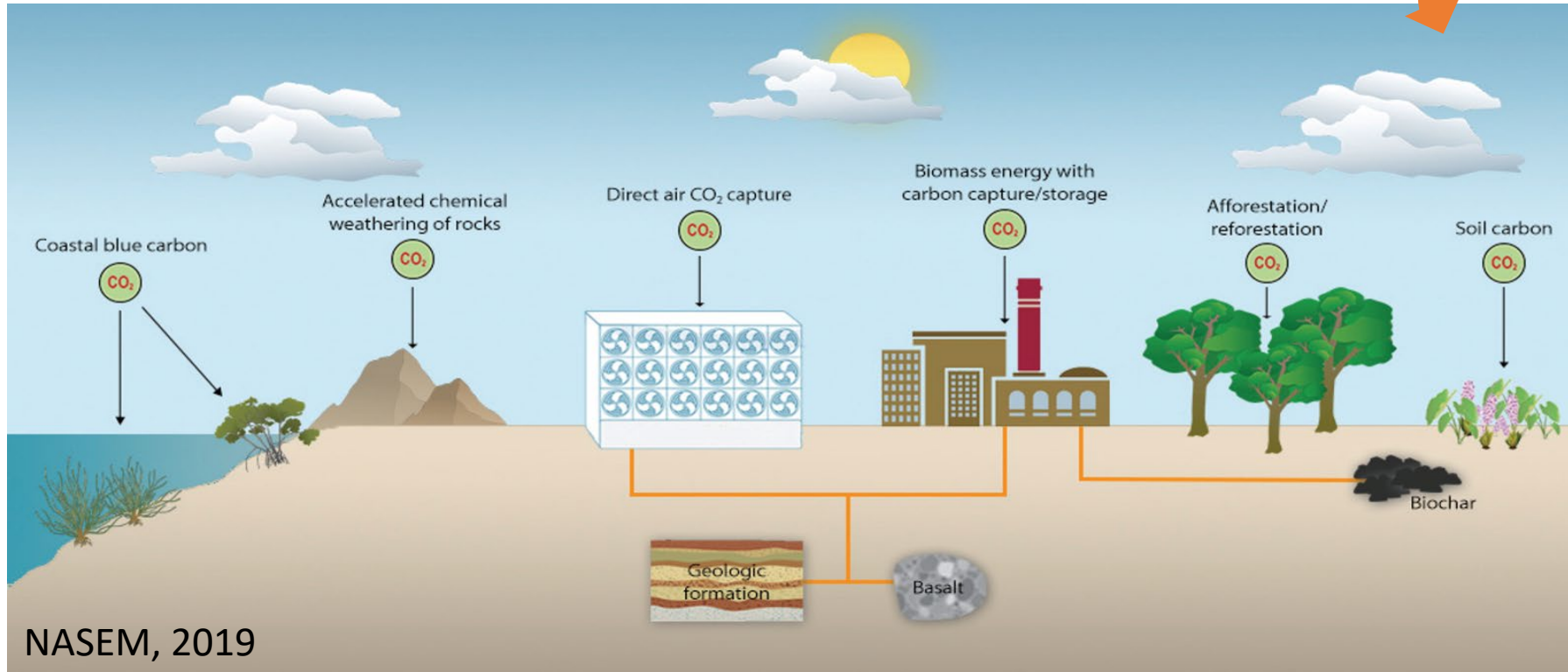
DAC coupled to steel plant waste heat: \$4.3m (\$3.5m federal) FEED study led by Univ. Illinois to be integrated with US Steel's Gary Works in Indiana, with CO₂ to be trucked to a ready-mix concrete plant to be mineralized into calcium carbonate. Photo: Adobe [296734139](#)

Engagement and Co-Benefits

Air Pollution Reduction Potential



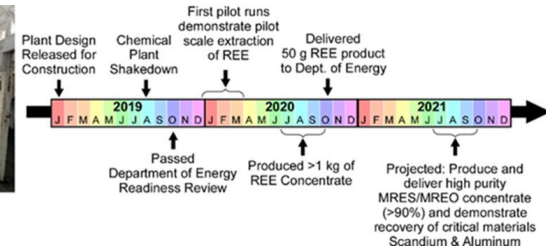
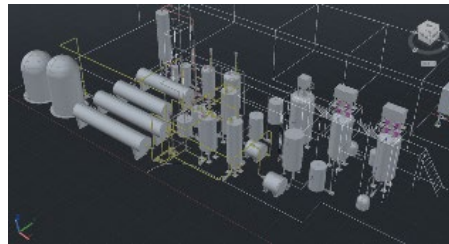
NASEM to Government Funding



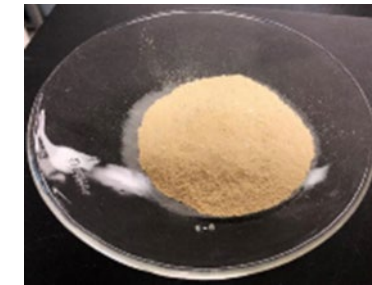
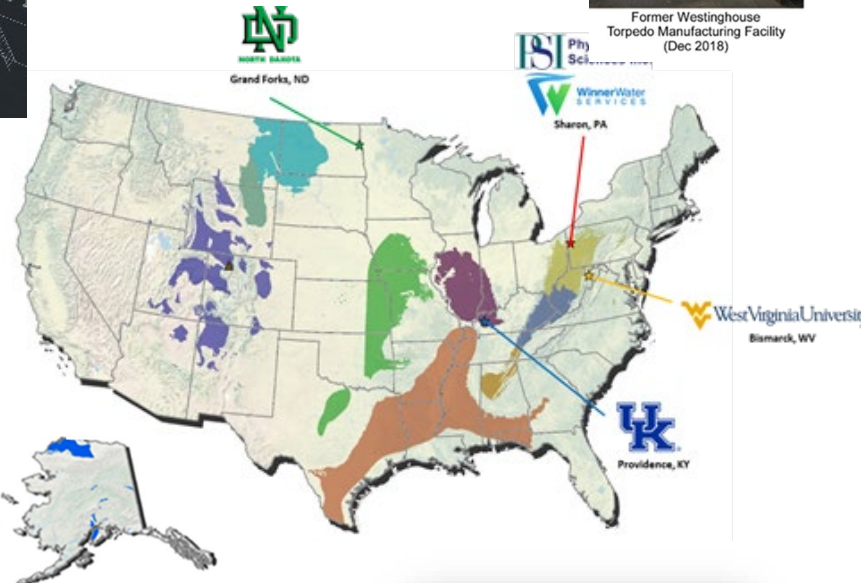
Durable and scalable carbon dioxide removal under \$100/net metric ton within a decade

Critical Minerals – Securing a Domestic Supply Chain

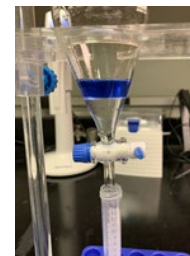
Small-Scale Pilots: Proving Technical Feasibility



REE Recovery Pilot Plant (Jan 2021)



	Quantity MREO Produced Annually			
	2018	2019	2020	2021
UKY-Refuse	0.6 kg @ 80% purity	1.5 kg @ >90% purity	0.5 kg @ ~98% purity	Processing Begins Fall
WVU-AMD	44 g @ 95-99% purity		Field-Pilot Construction (Facility Start-up January 2022)	
PSI-Ash	0.01 kg MRES @ ≤10% purity	0.149 kg MRES @ ≤14% purity	1.06 kg MRES @ ≤67% purity	1.76 kg of MRES @ ≤91% purity
	(0.004 kg MREO equivalent)	(0.057 kg MREO equivalent)	(0.41 kg MREO equivalent)	(0.67 kg MREO equivalent)
UND-Lignite	5-10 g @ 5-15% purity	500 g @ 30-85% purity	Pilot Construction (Facility Start-up October 2021)	
		4000 g @ 4-9% purity		



Bipartisan Infrastructure Law

\$6.5 billion in new carbon management funding over 5 years through the Infrastructure Investment and Jobs Act (Bipartisan Infrastructure Law).

Carbon Dioxide Removal - Direct Air Capture

Regional Direct Air Capture Hubs: \$3.5 billion
DAC Technology Prize Competition: \$115 million

Carbon Dioxide Utilization and Storage

Carbon Storage Validation and Testing: \$2.5 billion
Carbon Utilization Program: \$310 million

Front-End Engineering Design Studies

Carbon Capture Technology Program: \$100 million

Critical Minerals and Materials

Rare Earth Element Demonstration: \$140 million
Rare Earth Mineral Security: \$127 million

Office of Clean Energy Demonstrations (OCED)

OCED established December 2021

Principal Deputy Director, Kelly Cummins

- Builds on existing DOE investments in clean energy research and development
- Increases DOE's partnership with industry leaders

OCED Projects Areas:

- Clean hydrogen
- Carbon capture
- Grid-scale energy storage
- Small modular reactors and more

FECM-OCED Project Coordination

Hydrogen Hubs

- \$8 billion (for at least four projects, including at least one using fossil fuels with carbon management)

Carbon Capture Demonstrations and Large Pilots

- \$3.5 billion

Carbon Dioxide Transportation Infrastructure Finance and Innovation Program Account

- Loan Programs Office: \$2.1 billion

Thank You

Learn More About Us

The Office of Fossil Energy and Carbon Management

<https://www.energy.gov/fecm>

Our Office of Carbon Management

<https://www.energy.gov/fecm/office-carbon-management>

Our Strategic Vision

https://www.energy.gov/sites/default/files/2022-04/2022-Strategic-Vision-The-Role-of-Fossil-Energy-and-Carbon-Management-in-Achieving-Net-Zero-Greenhouse-Gas-Emissions_Updated-4.28.22.pdf