



U.S. DEPARTMENT OF  
**ENERGY**

Fossil Energy and  
Carbon Management

# Importance of Responsible Carbon Management to Decarbonization

**Dr. Emily Grubert**

DEPUTY ASSISTANT SECRETARY  
OFFICE OF CARBON MANAGEMENT



Legend:

- Light Rare Earth Elements
- Heavy Rare Earth Elements
- Critical Rare Earth Elements
- Critical Minerals

H	He																	He					
Li	Be																	B	C	N	O	F	Ne
Mg																	Al	Si	P	S	Cl	Ar	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr						
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe						
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn						
Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og						
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu									
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr									

\* Gas: K, Ar, Ne, Xe, Rn, He. \*\* Excluded with rare earth elements.



# Fossil Energy and Carbon Management (FECM)

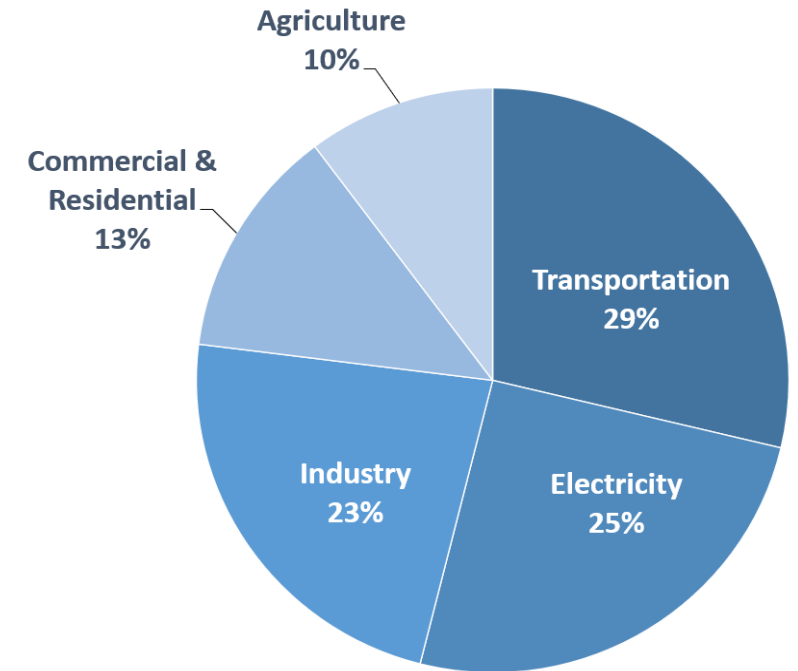
## Office of Fossil Energy and Carbon Management

DOE-FE is now DOE-FECM

New name for our office reflects our new vision

- President Biden's goals:
  - 50% emissions reduction by 2030
  - CO<sub>2</sub> 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

# FECM Mission: Deep Decarbonization and Environmental Justice

Minimize environmental and climate impacts of fossil fuels from extraction to use

## Priority Technology Areas

1. Point source carbon capture
2. Carbon dioxide (CO<sub>2</sub>) removal
3. CO<sub>2</sub> conversion into products
4. Reliable CO<sub>2</sub> storage
5. Hydrogen production

**Office of Carbon  
Management**  
(FECM-20)

6. Critical mineral production from industrial and mining waste
7. Methane mitigation

**Office of Resource  
Sustainability**  
(FECM-30)

## Enacting Justice and Supporting Legacy Communities

- Good-paying jobs
- Job growth acceleration
- Healthy economic transitions
- Improve community conditions

**Address hardest-to-decarbonize applications in the electricity and industrial sectors**

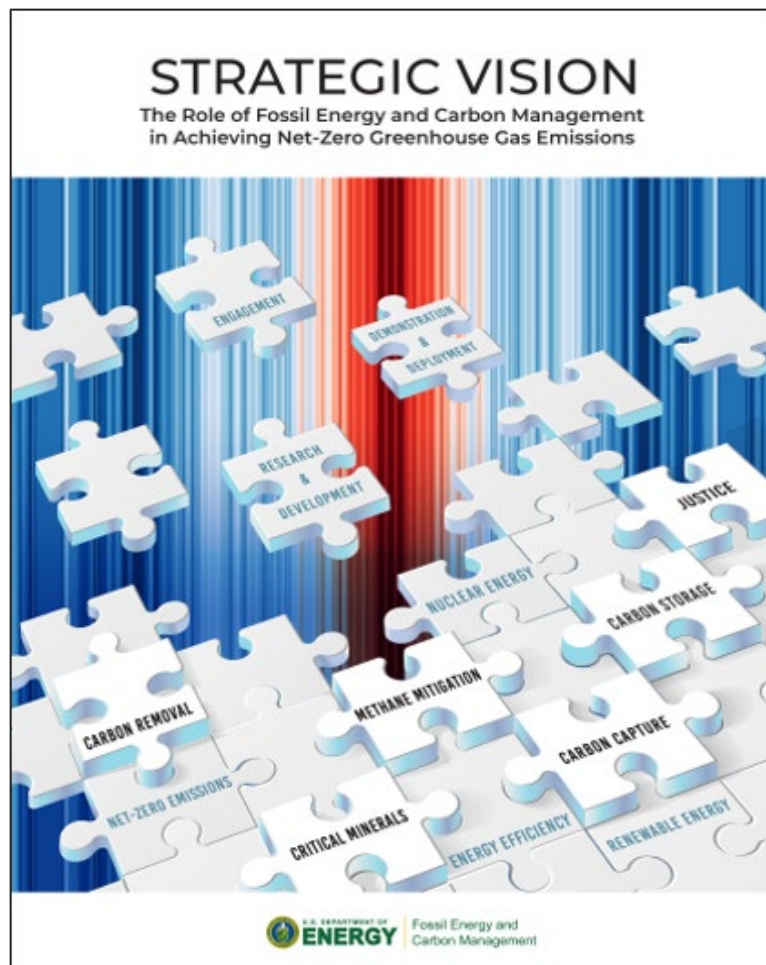


U.S. DEPARTMENT OF  
**ENERGY**

Fossil Energy and  
Carbon Management

[fecm.energy.gov](https://fecm.energy.gov)

# A Vision for Carbon Management



*A carbon management framework that will guide FECM's engagement with offices across the Department, Federal agencies, tribal and international governments, industry, non-governmental organizations, and communities*

## **Advancing Justice, Labor, and Engagement**

*Priorities: Justice, labor, and international and domestic partnerships*

## **Advancing Carbon Management Approaches Toward Deep Decarbonization**

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

## **Advancing Technologies that Lead to Sustainable Energy Resource**

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

# Bipartisan Infrastructure Law (BIL)

FECM - **\$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 – thoughtful siting w/ focus on hard to avoid sectors (e.g., industry and committed emissions)
- 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

# CCUS and CDR Facilitate Deep Decarbonization

## Reduce the cost of capture/increase rates

- Power Sector
- Industry
- Carbon Dioxide Removal
- Design Studies and Demonstrations

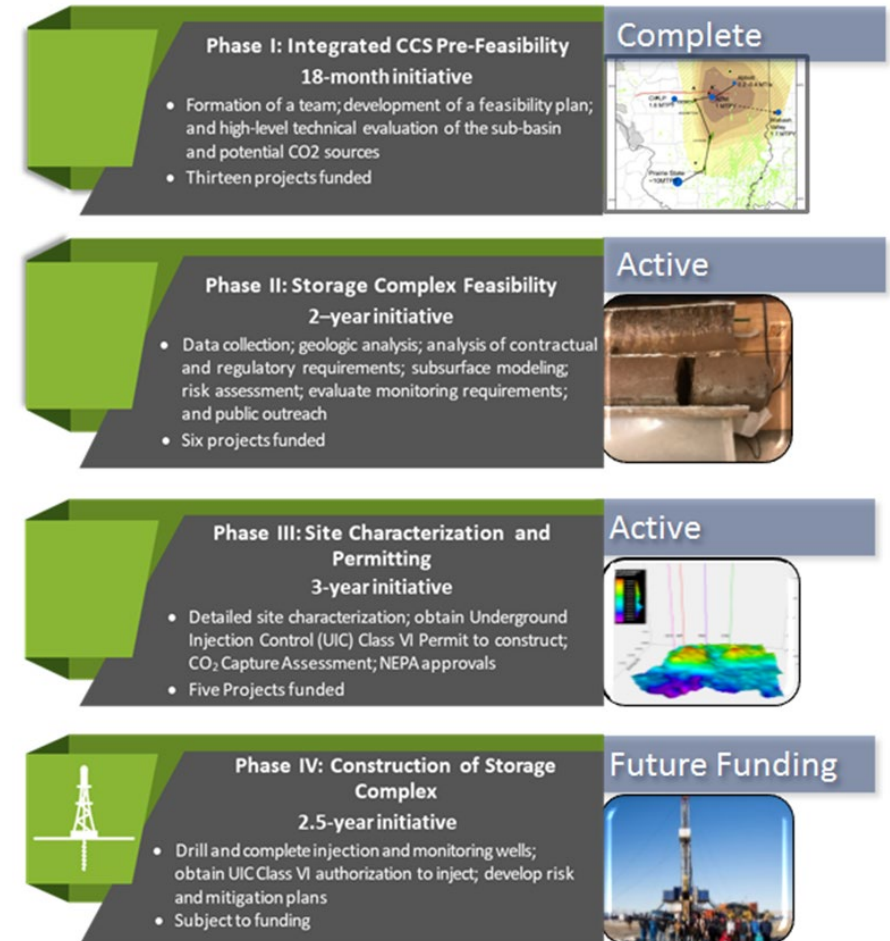
## Develop low-carbon supply chains through conversion

- Aggregates
- Fuels and Chemicals
- Solid Carbon Products

## Optimize geologic storage operations

- CarbonSAFE Infrastructure, Partnerships
- Geomechanics (pressure and state of stress)
- Conversion of fossil assets
- Enabling real-time decision making through AI

## CarbonSAFE - Infrastructure



# CO<sub>2</sub> Management Addresses Diverse Sources, and the CO<sub>2</sub> Concentration Affects Technical and Cost Challenges

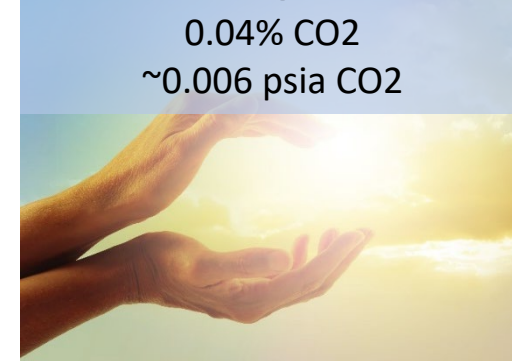
**Coal Power Plant**



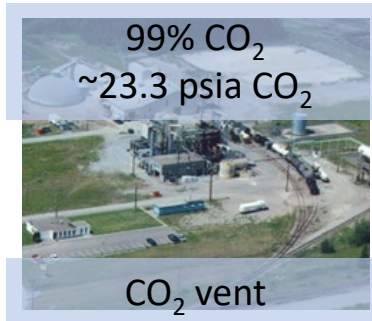
**Gas Power Plant**



**Air Capture**



**NG Processing Plant**



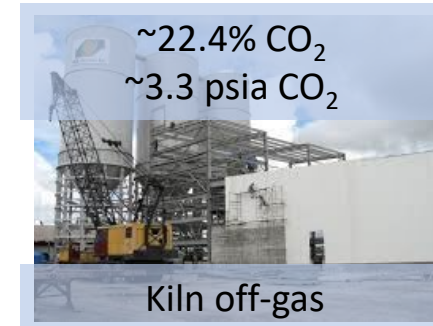
**Ammonia Plant**



**Ethanol Plant**



**Cement Plant**



Cost of Capturing CO<sub>2</sub> from Industrial Sources, January 10, 2014, DOE/NETL-2013/1602

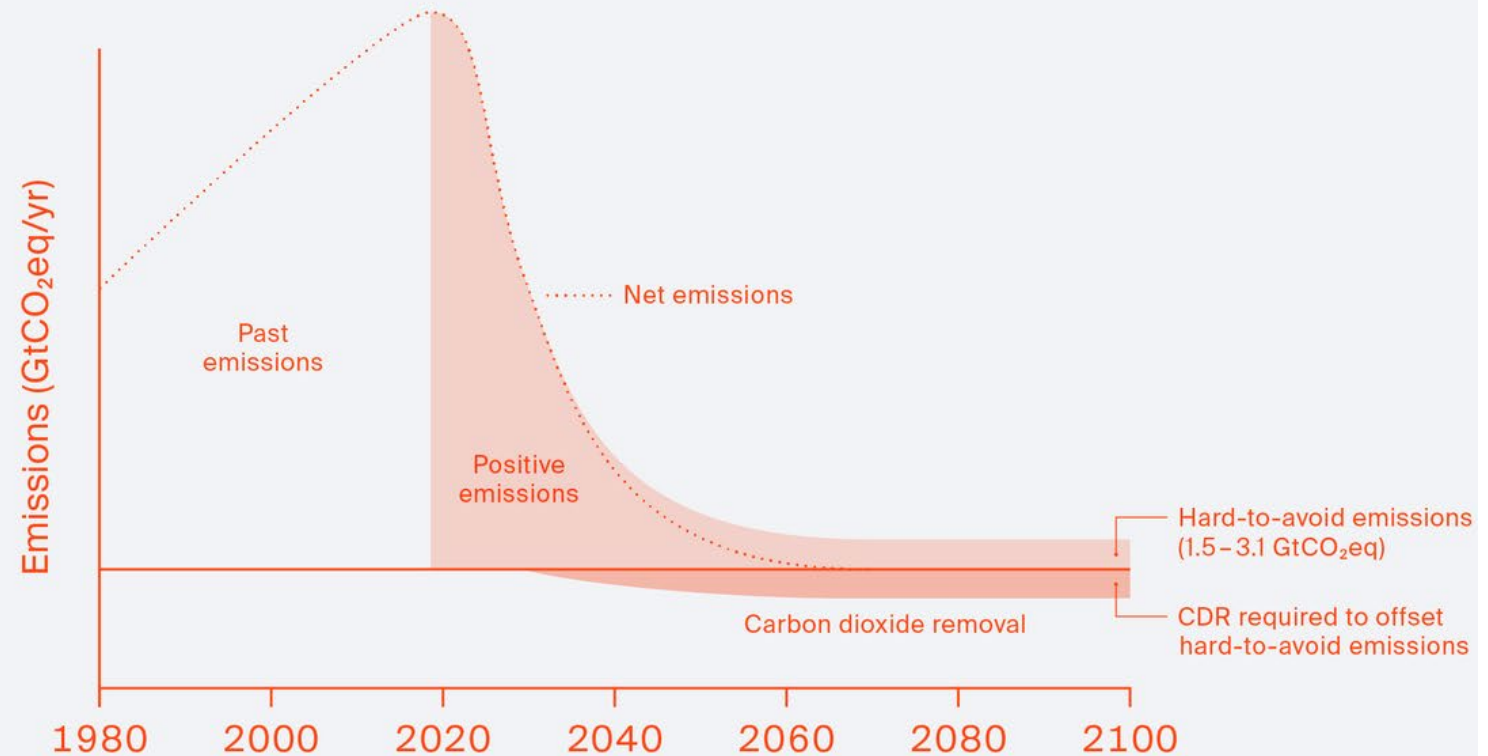


# Net-Zero and Role of Carbon Dioxide Removal

Figure

1.1 →

Schematic of hard-to-avoid emissions and the CDR needed to offset them. Adapted from a figure produced by Glen Peters (2020)



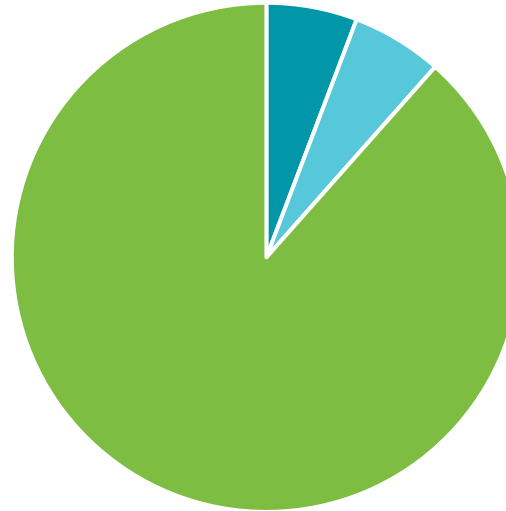
Reference: CDR Primer, 2021

# Carbon Negative Shot: Key Performance Elements

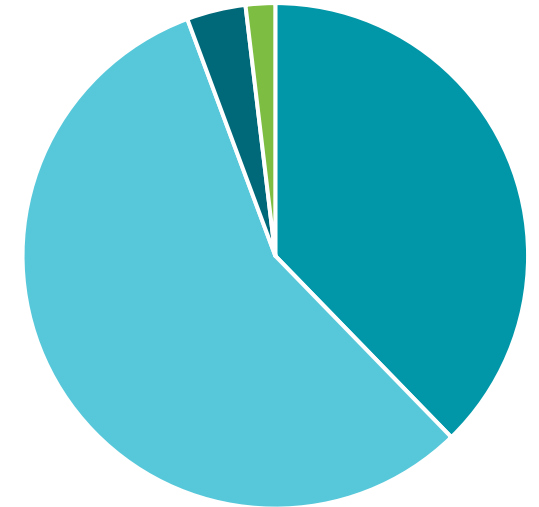
Carbon Negative Shot's key performance elements will guide a **responsible** industry that is **responsive** to the climate crisis, such that multiple true, durable removal pathways can be deployed at their most affordable cost at the scale required to address the climate crisis.

- 1 Less than **\$100/net metric ton CO<sub>2</sub>e** for both capture and storage
- 2 Robust accounting of full life cycle emissions
- 3 High-quality, durable storage with costs demonstrated for MRV for **at least 100 years**
- 4 Enables necessary **gigaton-scale** removal

Soil Carbon Sequestration



Direct Air Capture and Storage



**Blue** are costs associated with ambient air capture  
**Green** are costs associated with ensuring durable storage



U.S. DEPARTMENT OF  
**ENERGY**

Fossil Energy and  
Carbon Management

Ensure the first ton of removal  
is true, durable removal

Ensure the last ton of removal is  
as affordable as it can be



U.S. DEPARTMENT OF  
**ENERGY**

Fossil Energy and  
Carbon Management

# Questions?



Legend:

- Light Rare Earth Elements
- Heavy Rare Earth Elements
- Critical Rare Earth Elements
- Critical Minerals

																																																						He
H																	He																			He																		
Li	Be																	B	C	N	O	F	Ne																															
Mg																	Al	Si	P	S	Cl	Ar																																
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr																																					
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe																																					
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn																																					
Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og																																					
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu																																								
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr																																								

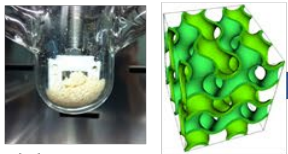
\* Gas: H, He, Ne, Ar, Kr, Xe, Rn; Liquid: Hg; Solid: All other elements. \*\* Excluded with rare earth elements.



# 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

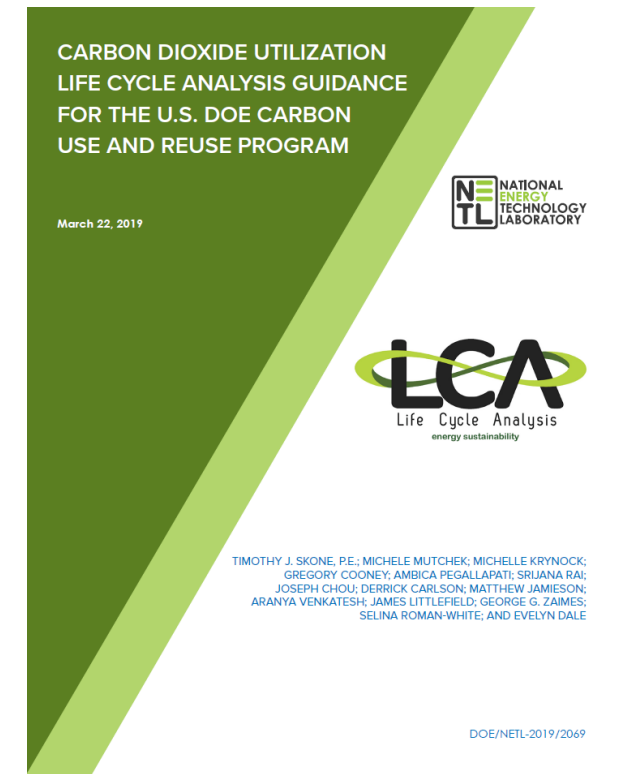
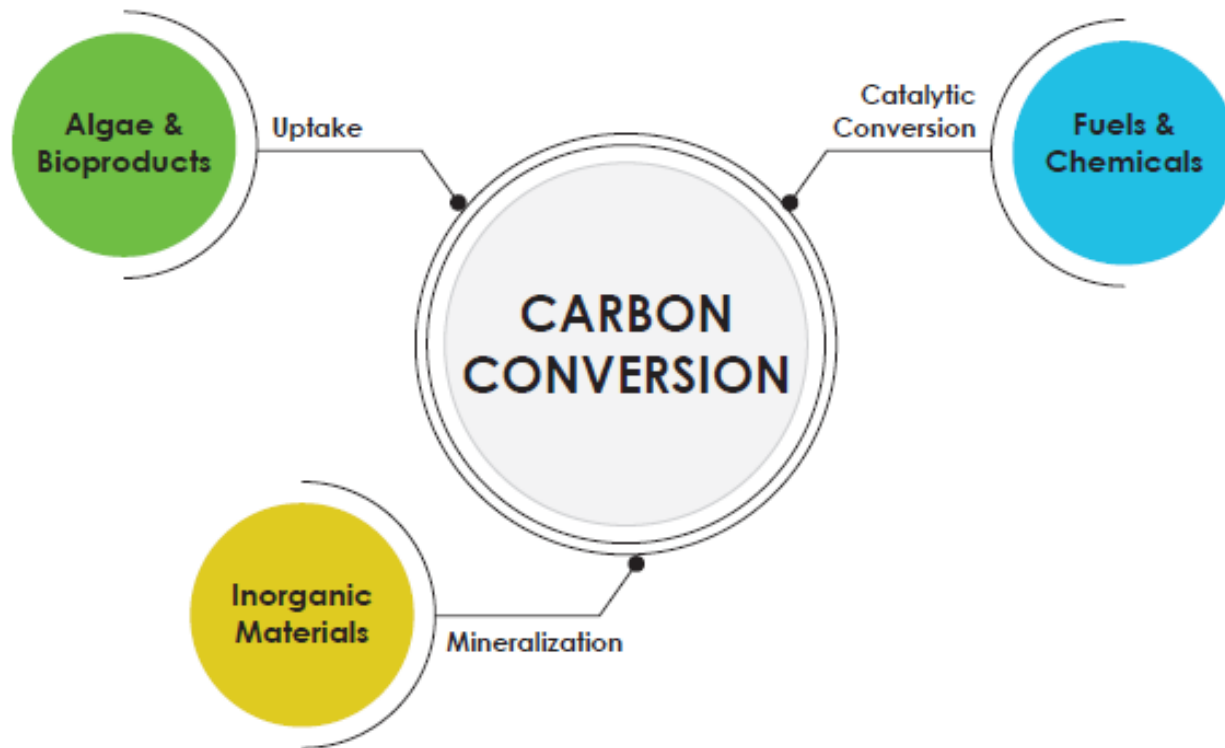
### FEED Studies



## Point Source Capture Focus

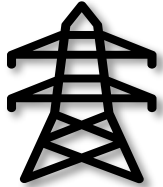
- Develop capture technologies for the power and industrial sectors
- Reduce CAPEX/OPEX under a wide range of feed conditions
- Achieve high capture efficiencies (>95%)
- Maximize co-benefit pollutant removal
- Engineering-based Simulation (CCSI<sup>2</sup>)
- Create low-carbon supply chains (i.e., cement, steel, hydrogen, etc.)

# CO<sub>2</sub> Conversion (the new “U”)





# Carbon Transport and Storage RD&D: An Iterative Process towards Deployment

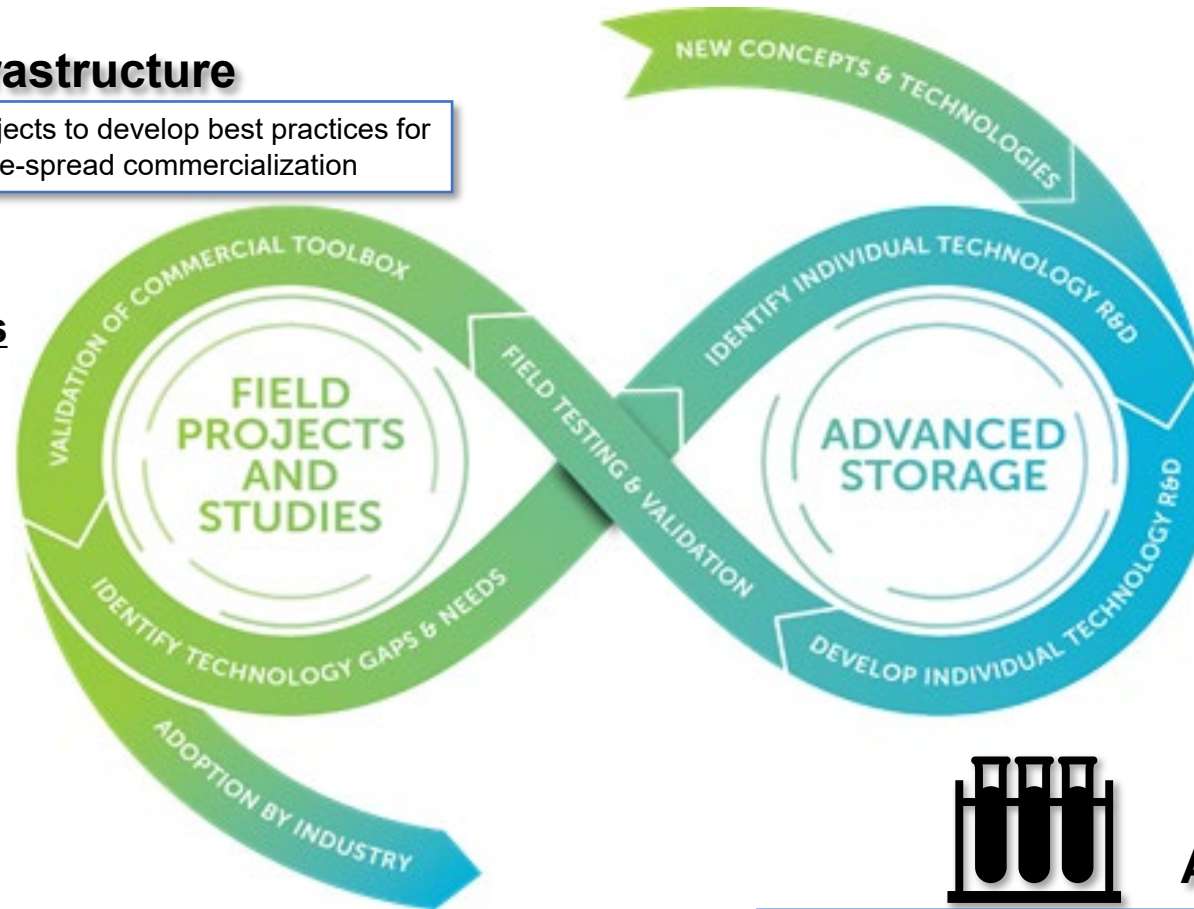


## Storage Infrastructure

Large-scale demonstration projects to develop best practices for industry and facilitate wide-spread commercialization

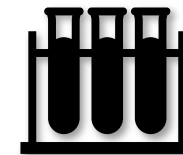
### Storage Infrastructure Focus

- CarbonSAFE
- Regional Initiatives
- Offshore Storage
- Brine Extraction Strategy Test (**BEST**)
- Transition of O&G infrastructure



### Advanced Storage Focus

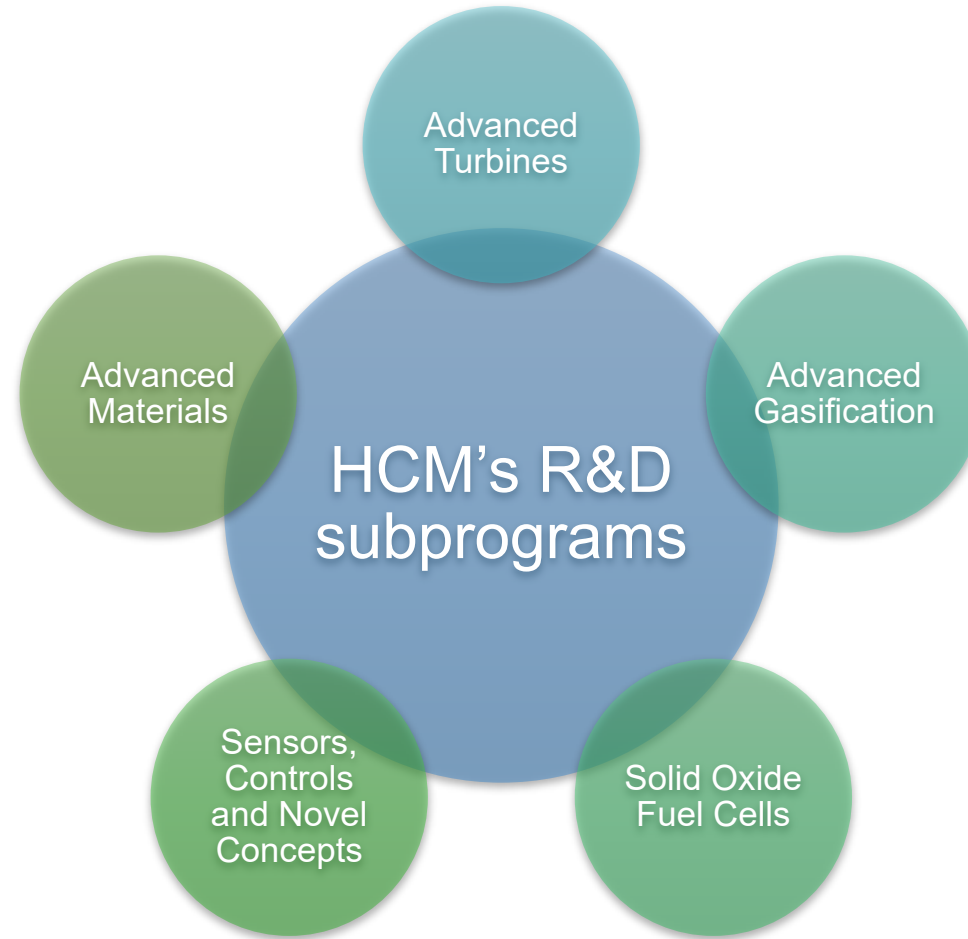
- Well Integrity and mitigation
- Monitoring, verification, and accounting
- Storage complex efficiency and security
- **SMART: Science-Informed Machine Learning for Accelerating Real Time Decisions**
- **NRAP: National Risk Assessment Partnership**



## Advanced Storage

Harness early-stage storage concepts to technology demonstration

# Hydrogen with Carbon Management Division



# CDR Areas of Interest in FECM

- Biomass with Carbon Removal and Storage
- Direct Air Capture (DAC)
- Direct Ocean Capture (DOC)
- Accelerated Weathering and Mineralization

- Rigorous LCA and TEA (net-removed costs)
- Low-carbon energy, land, water resources required
- Leveraging transport and storage infrastructure
- Justice and work force considerations

