U.S. DEPARTMENT OF ENERGY
Fossil Energy and Carbon Management

OFFICE OF CARBON MANAGEMENT TECHNOLOGIES

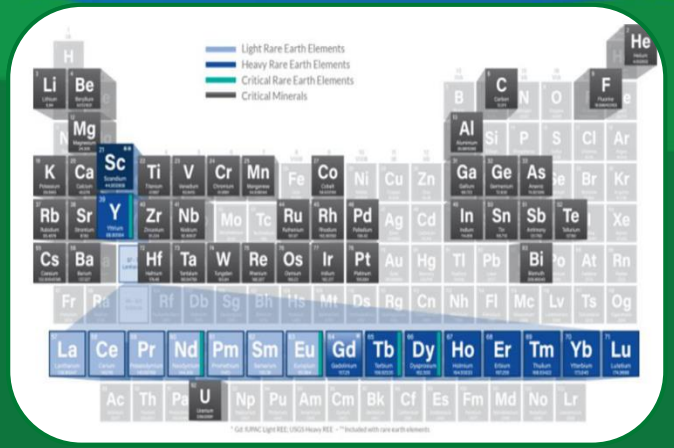
CIBO update

Lynn Brickett
Division Director of Point Source Capture

Amishi Claros
Acting Division Director of CDR & Conversion

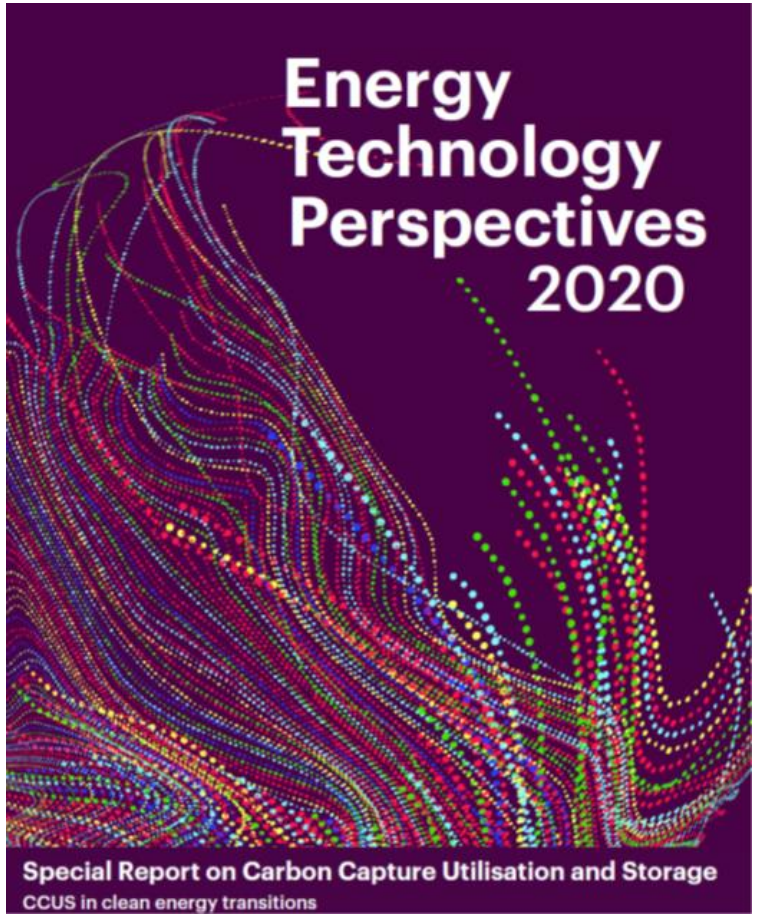
September 2022





The Role of CCUS: Critical to addressing the challenge

- CCUS will need to form a key pillar for efforts to put the world on a path to net zero emissions
- Reaching net zero will be virtually impossible without CCUS
- CCUS tackles emissions from existing infrastructures – power, heavy industry
- CCUS is one of two pathways to low carbon hydrogen
- Remove carbon from the atmosphere
- Moving the de-carbonization goal from 2070 to 2050 - requires increasing CCUS by 50% over past applications



Fossil Energy and Carbon Management (FECM)

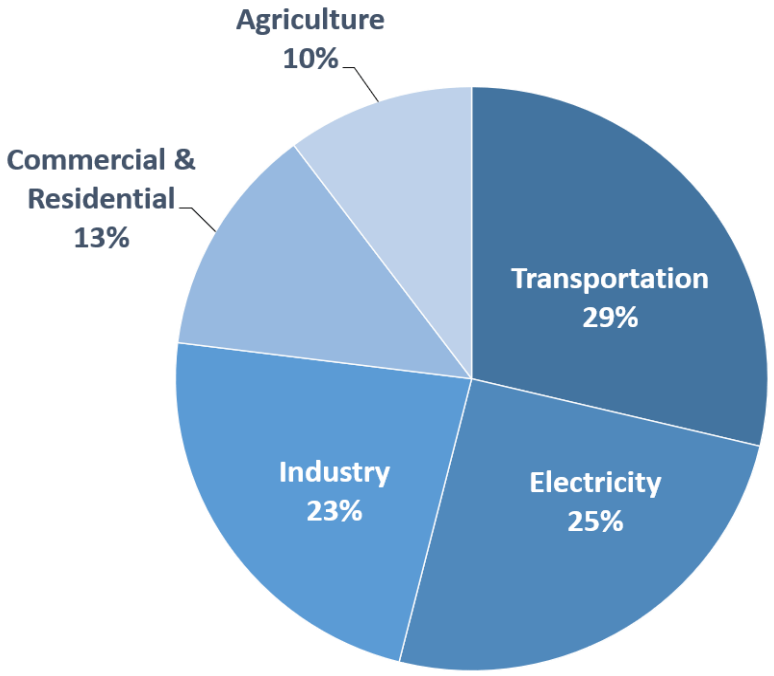
Office of Fossil Energy and Carbon Management

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_2 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_2) removal
3. CO_2 conversion into products
4. Reliable CO_2 storage
5. Hydrogen production

Office of Carbon Management
(FECM-20)

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

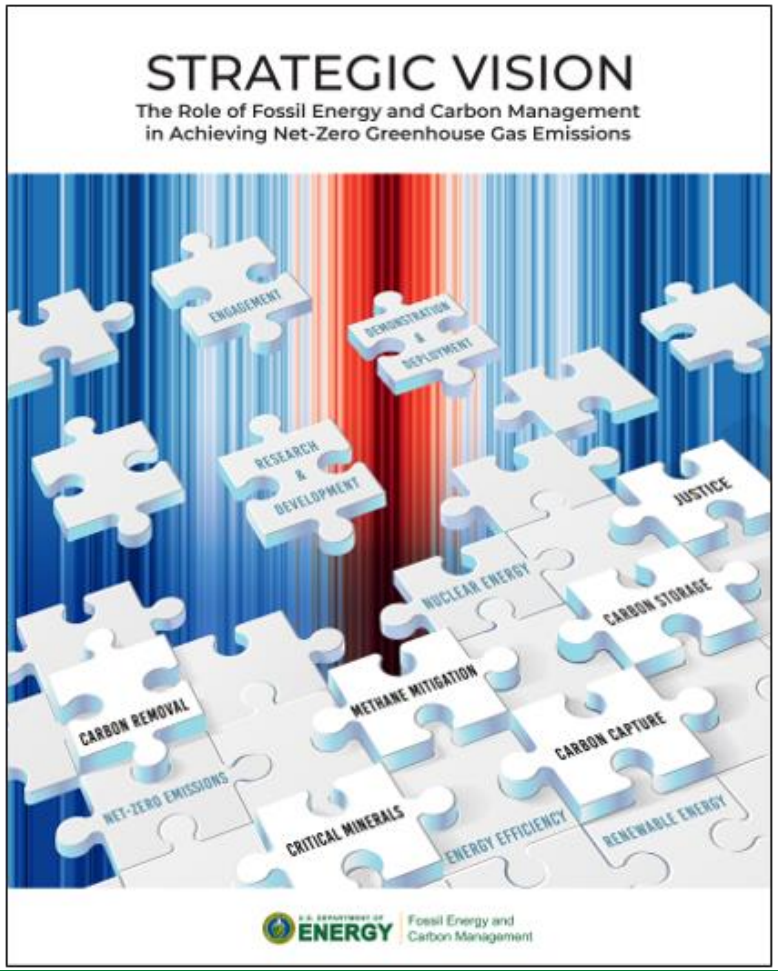
Office of Resource Sustainability
(FECM-30)

Societal Consideration and Impacts

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

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

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

- 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

Inflation Reduction Act – 45Q Modifications

	Old	New
Commence Construction	January 1, 2026	January 1, 2033
DAC Facility	100,000 metric tons/year*	1,000 metric tons/year
Electric Generator	500,000 metric tons/year*	18,750 metric tons/year
All other facilities	100/000 metric tons/year*	12,500 metric tons/year
Saline Storage Credit	$50/metric ton	$85/metric ton (industry and power); $180/metric ton (DAC)
EOR and Conversion Credit	$35/metric ton	$60/metric ton (industry and power); $130/metric ton (DAC)

** Non-EOR Conversion facilities were previously 25,000 metric tons/year regardless of facility/source.*

Notes: New Modifications allows up to 5 years for direct pay (up to 12 years certain entities)

Carbon Dioxide Removal

Removal of atmospheric CO_2 and durable store

Carbon Utilization

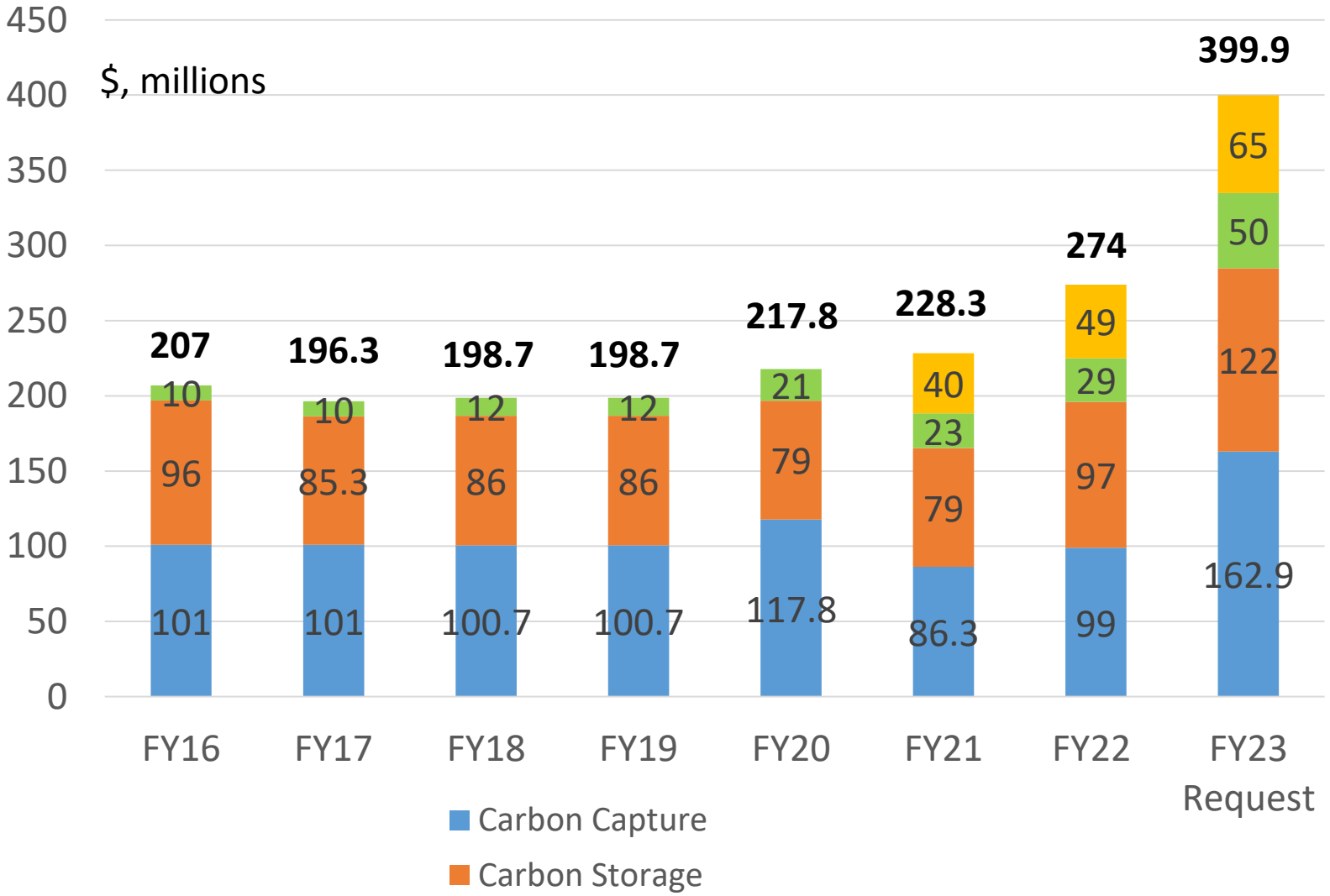
Conversion of CO_2 to value-added products

Carbon Storage

Safe, cost- effective, and permanent geologic storage of CO_2

Carbon Capture

Capturing CO_2 from new and existing industrial and power plants



Part 1 (Amishi)

- Mission Innovation: CDR Mission
- DAC Prize
- RCC

CARBON DIOXIDE REMOVAL MISSION

The Goal: Enable Carbon Dioxide Removal technologies to achieve a net reduction of 100 million metric tons of CO_2 per year globally by 2030.

The Mission: We will catalyse a global CDR industry by advancing research and development for CDR technologies[1], harmonizing lifecycle analyses (LCAs) and technoeconomic analyses (TEAs), and facilitating near-term pilot-scale tests and deployment.

[1] Including direct air capture (DAC), biomass with carbon removal and storage (BiCRS), and enhanced mineralization.

Co-leads: United States, Saudi Arabia, Canada

Core Mission Members: Norway, Gassnova

Mission Support Group:

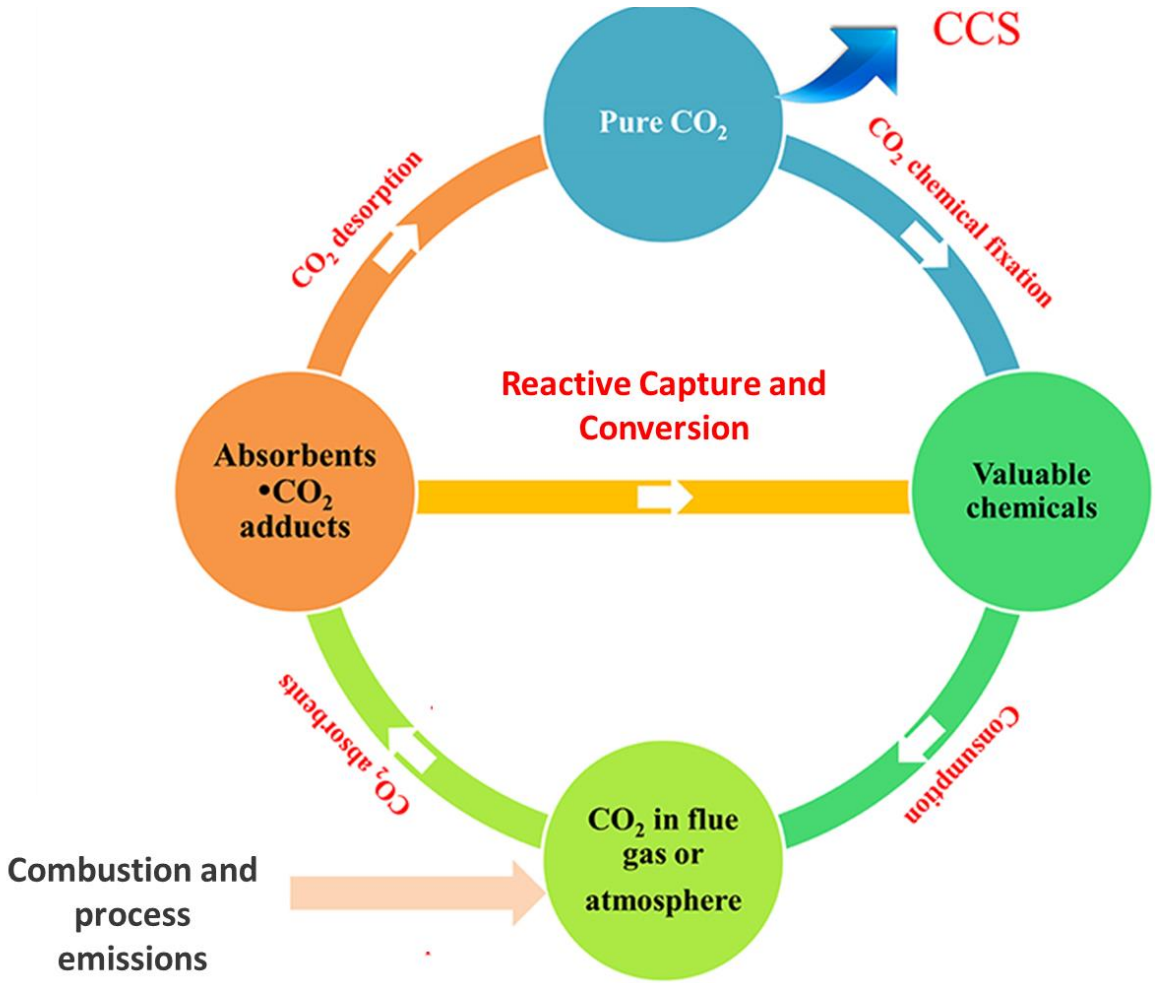
- Australia, national Commonwealth Scientific and Industrial Research Organization (CSIRO)
- European Commission, Directorate-General for Research & Innovation
- Japan, Ministry of Economy, Trade and Industry
- India, Ministry of Science and Technology (DBT and DST)

What is RCC?

Reactive capture and conversion may comprise the integration of CO_2 separation and conversion in a method using fewer steps, one reactor, or simply process intensification (reduced unit operations) in the pathway from CO_2 in a mixed gas stream to a CO_2-derived product.

Great reference alert!

Joint lab (NREL, LLNL, LBNL, and NETL) workshop on RCC with proceedings webpage: https://www.nrel.gov/bioenergy/workshop-reactive-co2-capture-2020-proceedings.html
and online published report: https://www.nrel.gov/docs/fy21osti/78466.pdf.



Lawrence Livermore National Lab LLNL

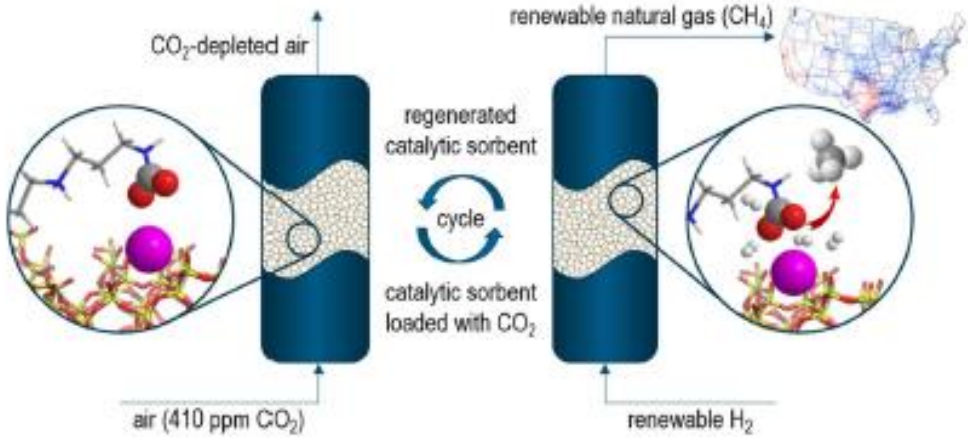
Develop a RCC technology of dual-functional materials capable of capturing CO2 directly from the air and converting it into renewable natural gas (RNG) using renewable hydrogen. Sourcing carbon from the air allows production of climate-neutral fuel

PI: Dr. Simon Pang LLNL

Team: NREL

Objectives

- Develop highly selective and oxidatively stable amines to capture CO2 directly from the air
- Atomically dispersed metal catalysts enable low-temperature CO2 methanation



Relevance and Outcomes/Impact

- The resulting technology addresses an urgent and growing need for natural gas grid decarbonization and utility-scale seasonal energy storage.

Pre-commercial DAC Prize Section 41005a

‘‘(A) PRECOMMERCIAL AIR CAPTURE PROJECTS.—With respect to projects described in paragraph (2)(A), to be eligible to be awarded a prize under the prize competition, a project shall—

‘‘(i) meet ***minimum performance standards*** set by the Secretary;

‘‘(ii) meet ***minimum levels set*** by the Secretary for the capture of carbon dioxide from dilute media; and

‘‘(iii) demonstrate in the application of the project for a prize—
‘‘(I) a design for a promising carbon capture technology that will—
‘‘(aa) be operated on a demonstration scale; and
‘‘(bb) have the potential to achieve significant reduction in the level of carbon dioxide in the atmosphere;
‘‘(II) a ***successful bench-scale demonstration*** of a carbon capture technology; or
‘‘(III) an *operational carbon capture technology* on a commercial scale.

Commercial DAC Prize Section 41005b

‘‘(B) COMMERCIAL DIRECT AIR CAPTURE PROJECTS.—

‘‘(i) IN GENERAL.—With respect to projects described in paragraph (2)(B), the Secretary shall award prizes under the prize competition to qualified ***direct air capture facilities*** for metric tons of qualified carbon dioxide captured and verified at the point of disposal, injection, or utilization.

‘‘(ii) AMOUNT OF AWARD.—The amount of the award per metric ton under clause (i)—‘‘(I) shall be equal for each qualified direct air capture facility selected for a prize under the prize competition; and

‘‘(II) shall be determined by the Secretary and in any case shall not exceed—

‘‘(aa) **$180 for qualified carbon dioxide captured** and stored in saline storage formations;

‘‘(bb) a lesser amount, as determined by the Secretary, for qualified carbon dioxide captured and stored in conjunction with enhanced oil recovery operations; or

‘‘(cc) a lesser amount, as determined by the Secretary, for qualified carbon dioxide captured and utilized in any activity consistent with section 45Q(f)(5) of the Internal Revenue Code of 1986.

‘‘(iii) REQUIREMENT.—The Secretary shall make awards under this subparagraph until appropriated funds are expended.

Part II (Lynn)

- Carbon Negative Shot
- Annual R&D Program
- DAC HUB

ENERGY earthshots
U.S. DEPARTMENT OF ENERGY

Carbon Negative™

Carbon Negative Shot is an all-hands-on-deck call for innovation in CDR pathways that will capture CO_2 from the atmosphere and store it at gigaton scales

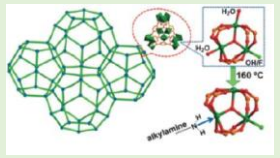
Direct Air Capture (DAC): R&D Activities

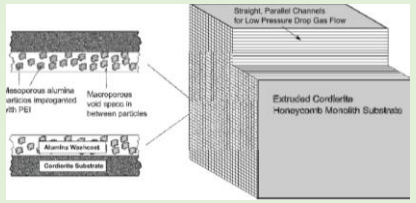
As a leader in advancing carbon management technologies, FECM is **researching and investing in DAC technologies** to help scale them up for the commercial market.

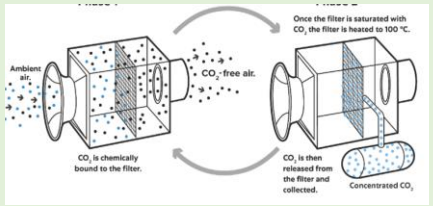
2020-Present: Laboratory Material and Process Development

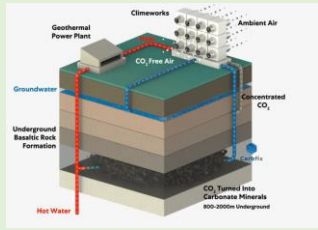
2018	2019	2020	2021	2022
2018: FECM kicks off DAC R&D efforts	**2019:** Workshop for DAC R&D Priorities	**2020:** Techno-Economic Assessment, National Resources Assessment, DAC Investment ($72M, Sep. 2020)	**June 2021:** $12M DAC Investment **Aug. 2021:** $6M DAC Investment **Oct. 2021:** $14.5M DAC investment	**2022:** FECM co-funds DAC FEED study at Geothermal or Nuclear plant

DAC Technology Development









	Materials	Structured Material Systems /Components		Bench Scale/ Integrated system	Field Demo Integrated System	Pre- FEED /FEED	
Gen 1				FOA 2402 $8M FY 21		FOA 2402 $7.5M FY 20	FOA 2560 FY 22?
Gen 2	FOA 2188 $11M FY 20-21	FOA 2402 $10.2M FY 21	NOI 2684 FY 22	NOI 2684 FY 22?			

Carbon Management FOA CDR Topics

AOI-2A. CDR R&D: Bench-Scale Testing of Structured Material Systems, or Components Designs for Optimized **Direct Air Capture**

AOI-2B. CDRl R&D: Bench-Scale Testing of Optimized **Direct Air Capture** Integrated Processes

AOI-2C. Initial Engineering Design Studies for Advanced Carbon Capture Systems at Existing **Power Plant** Facilities Utilizing **Biomass**

AOI-2D. Initial Engineering Design Studies for Advanced Carbon Capture Systems at **Industrial** Facilities Producing **Net Carbon-Negative Fuels** Utilizing **Biomass**

AOI-2E. **Initial Engineering Design Studies for Advanced Carbon Capture Systems at Iron and Steel, Cement and Lime, or Pulp and Paper Plants Utilizing Biomass**

Initial Engineering Design of Carbon Capture Utilization and Storage Systems (TRL 6) for Direct Air Capture

Execute early-stage engineering designs for DAC technology – The Black & Veatch Corporation team will develop an initial engineering design of a DAC system to be placed in Odessa, Texas, Bucks, Alabama, and Goose Creek Illinois, aimed at capturing 100,000 tonnes of CO_2 from the atmosphere per year. **(Award amount: $2,500,000)**

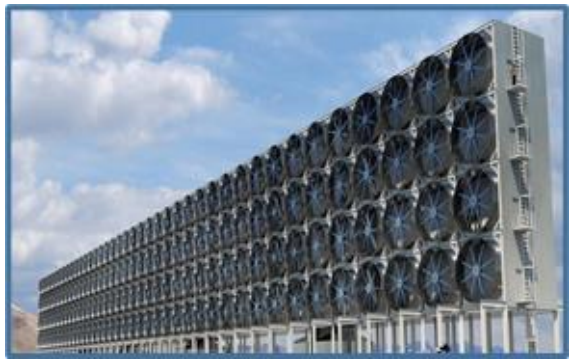
Implement an initial design of three carbon farms using a commercial-scale DAC system - Silicon Kingdom Holdings Limited will complete three initial designs using a commercial-scale, passive DAC system that absorbs CO_2. This design, developed at the Arizona State University (Tempe, AZ), aims to capture a steady capacity of 1,000 tonnes of CO_2 per day. **(Award amount: $2,500,000)**

Utilize low-carbon energy sources to power commercial scale DAC operations - The University of Illinois (eam will develop preliminary designs for large-scale direct air capture and work with partners to perfect the designs to permanently store CO_2 at underground facilities in Wyoming, Louisiana and California. In addition to examining the effects of different climate conditions, the project will measure the impact of using different low-carbon power sources (e.g., geothermal, solar, wind or waste heat) to reduce the life-cycle emissions of DAC technology. **(Award amount: $2,499,798)**

Direct Air Capture Hubs Summary of Provision Requirements

Direct Air Capture (DAC) Hubs

SEC. 40308. CARBON REMOVAL; *Amended Section 969D of the Energy Policy Act of 2005 (42 U.S.C. 16298d)*



$3.5 B FY 22 – FY 26: $700M / yr.

HUB DEFINITION:

a network of direct air capture projects, potential carbon dioxide utilization offtakers, connective carbon dioxide transport infrastructure, subsurface resources, and sequestration infrastructure located within a region.

ESTABLISHMENT OF PROGRAM.

The Secretary shall establish a program under which the Secretary shall provide funding for eligible projects that contribute to the development of 4 regional direct air capture hubs. Each of the 4 regional DAC hubs:

(i) facilitates the deployment of direct air capture projects;
(ii) has the capacity to capture and sequester, utilize, or sequester and utilize at least 1,000,000 metric tons of carbon dioxide from the atmosphere annually from a single unit or multiple interconnected units;
(iii) demonstrates the capture, processing, delivery, and sequestration or end use of captured carbon; and
(iv) could be developed into a regional or interregional carbon network to facilitate sequestration or carbon utilization.

IIJA SEC. 40308 / DAC Regional Hubs -- Selections

SOLICITATION OF PROPOSALS.—

(i) IN GENERAL.— Not later than 180 days after the date of enactment of the Infrastructure Investment and Jobs Act, the Secretary shall solicit applications for funding for eligible projects.

(ii) ADDITIONAL SOLICITATIONS.— The Secretary shall solicit applications for funding for eligible projects on a recurring basis after the first round of applications is received under clause (i) until all amounts appropriated to carry out this subsection are expended

SELECTION OF PROJECTS FOR THE DEVELOPMENT OF REGIONAL DIRECT AIR CAPTURE HUBS: Not later than 3 years after the date of the deadline for the submission of proposals

COORDINATION: To the maximum extent practicable, take into account and coordinate with activities of the carbon capture technology program established under section 962(b)(1), the carbon storage validation and testing program established under 18 section 963(b)(1), and the CIFIA program established under section 999B(a) such that funding from each of the programs is leveraged to contribute toward the development of integrated regional and interregional carbon capture, removal, transport, sequestration, and utilization networks.

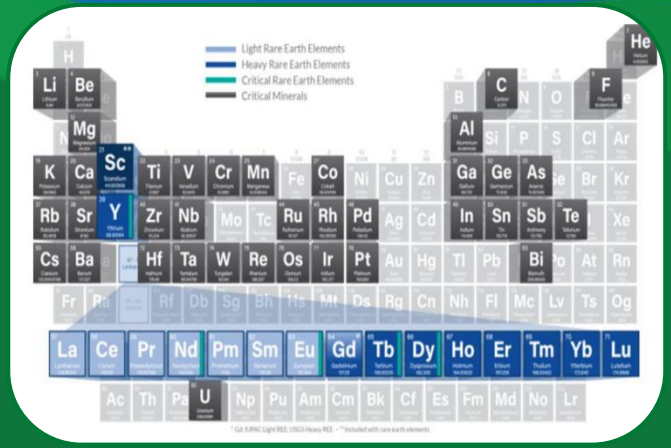
IIJA SEC. 40308 / DAC Regional Hubs -- Criteria

- (i) **CARBON INTENSITY OF LOCAL INDUSTRY**. located in a region with— (I) existing carbon-intensive fuel production or industrial capacity; or (II) carbon-intensive fuel production or industrial capacity that has retired or closed in the preceding 10 years.
- (ii) **GEOGRAPHIC DIVERSITY**
- (iii) **CARBON POTENTIAL**—located in regions with high potential for carbon sequestration or utilization.
- (iv) **HUBS IN FOSSIL-PRODUCING REGIONS** contribute to the development of at least 2 regional direct air capture hubs located in economically distressed communities in the regions of the United States with high levels of coal, oil, or natural gas resources.
- (v) **SCALABILITY**.—give priority to eligible projects that, as compared to other eligible projects, will contribute to the development of regional direct air capture hubs with larger initial capacity, greater potential for expansion, and lower levelized cost per ton of carbon dioxide removed from the atmosphere.
- (vi) **EMPLOYMENT**.—give priority to eligible projects that are likely to create opportunities for skilled training and long-term employment to the greatest number of residents of the region.
- Additional Criteria as determined.

U.S. DEPARTMENT OF ENERGY

Fossil Energy and Carbon Management

Questions?



Office of Clean Energy Demonstrations (OCED)

OCED established December 2021

- 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