August 2023

Carbon Dioxide Removal (CDR) Program

Rory Jacobson

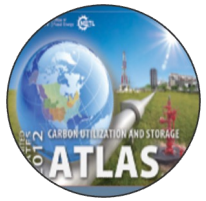
SENIOR ADVISOR FOR DEPLOYMENT
OFFICE OF FOSSIL ENERGY AND CARBON MANAGEMENT

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

H_2 with Carbon Management
Conversion of carbon-based feedstocks to H2 coupled with carbon management

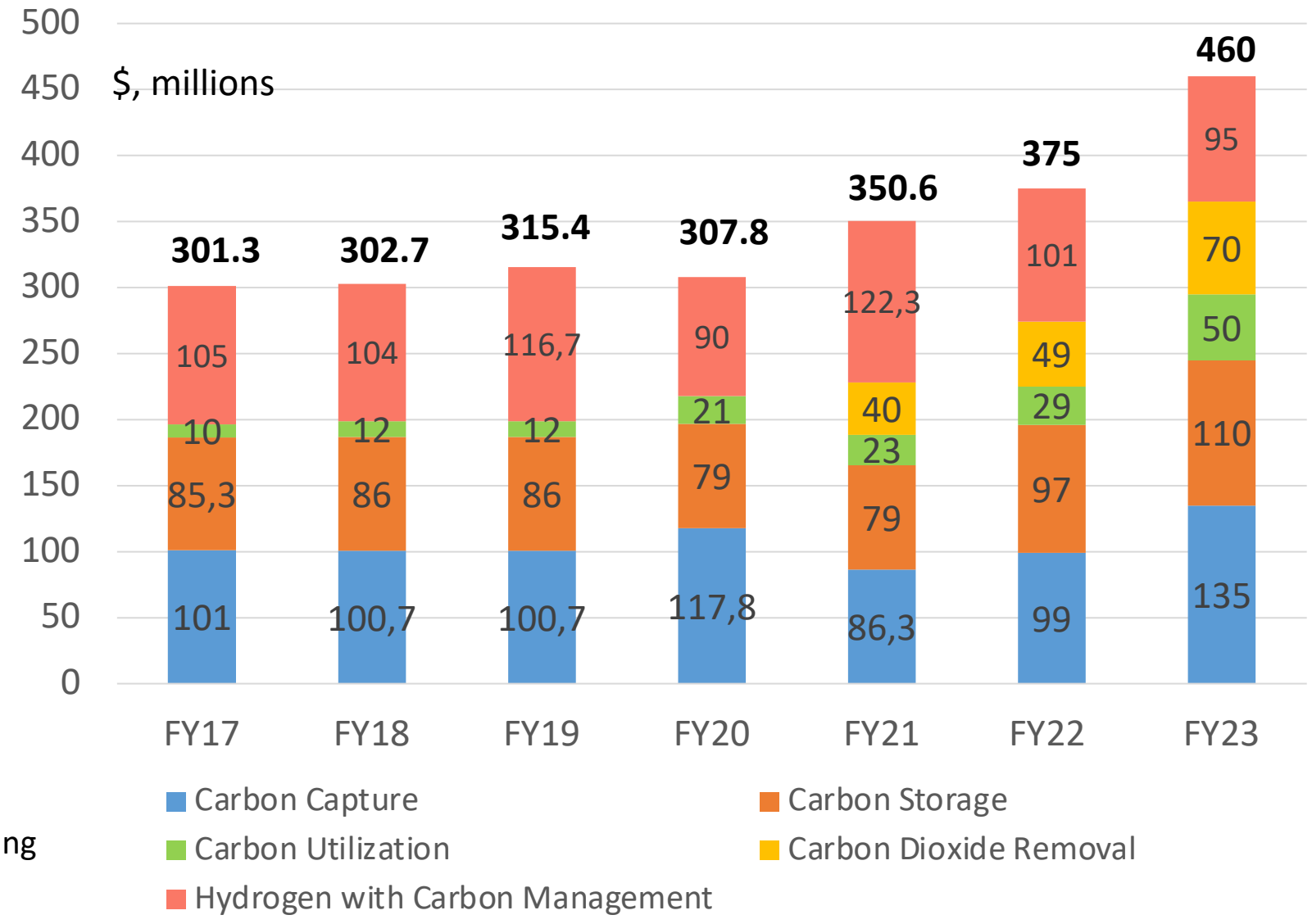
Carbon Dioxide Removal
Removal of atmospheric CO_2 and durable store

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



Energy Earthshot: Carbon

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

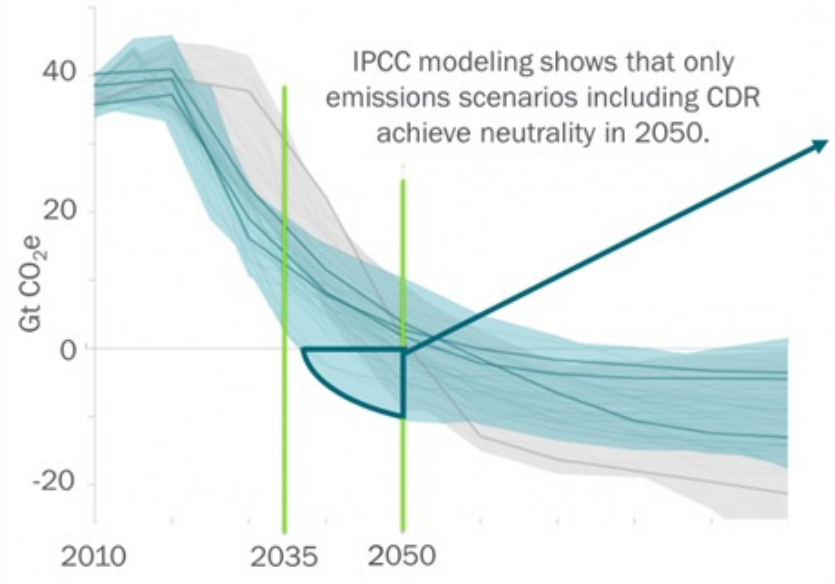
Carbon Shot defines key performance elements for a **necessary** and **nascent** industry which can help ensure CDR is a **responsive** and **responsible** tool for addressing the climate crisis.

1. Less than $100/metric ton CO_2e for both capture and storage
2. Robust **accounting**
3. Durable **100-year** storage
4. Enables necessary **gigaton-scale** removal

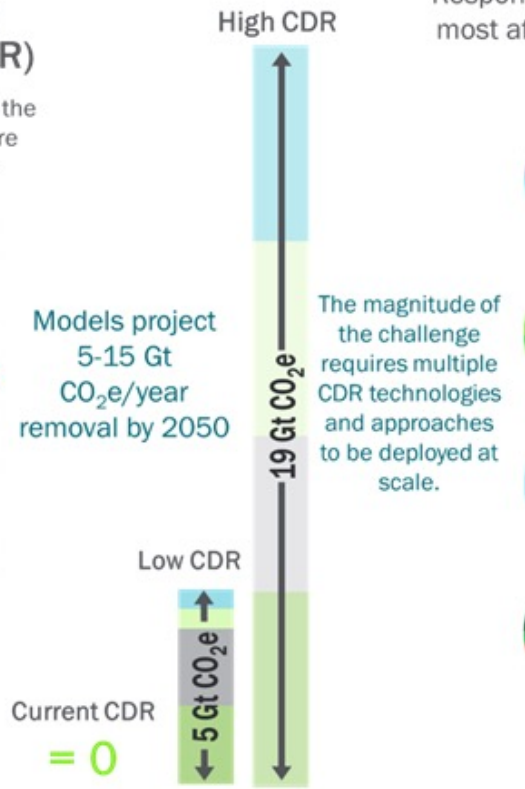
Necessary

NET ZERO Administration goals indicate a *required* role for carbon dioxide removal (CDR)

Distinct from point source carbon capture and storage of emissions from the fossil power sector and heavy-duty industry, CDR are activities that capture CO_2 from the atmosphere and durably store it in geological, biobased, or ocean reservoirs, or in products to create negative emissions.

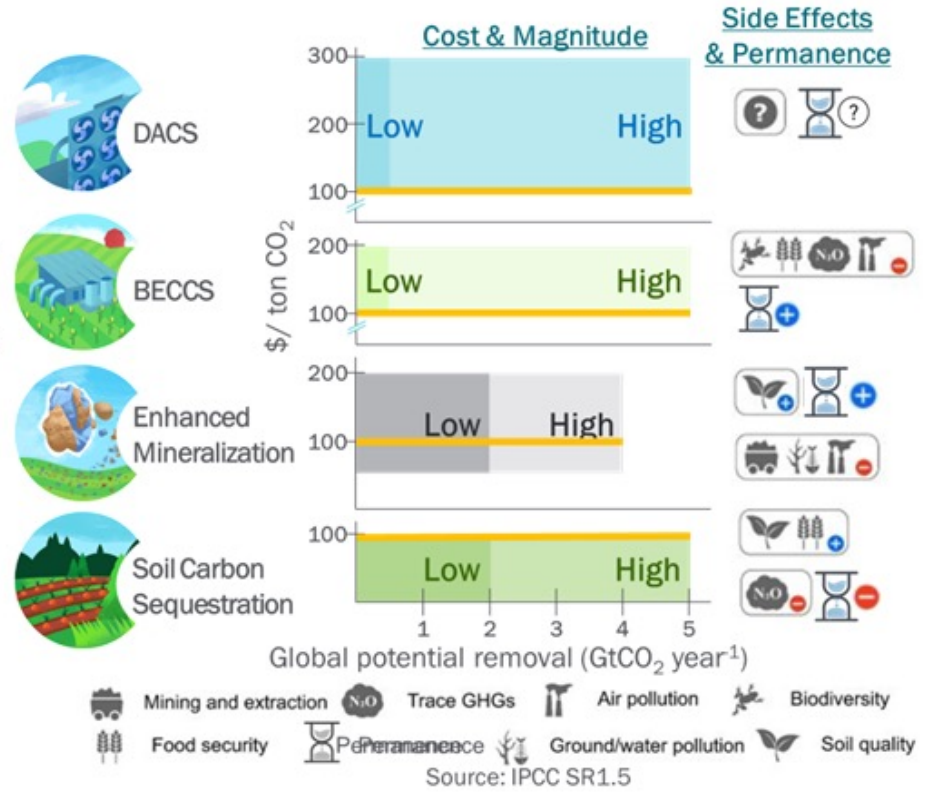


Nascent



Responsive and responsible

Responsive in that multiple technologies can be deployed at their max scale at the most affordable cost in a responsible manner that ensures true, durable removal.



Source: IPCC SR1.5

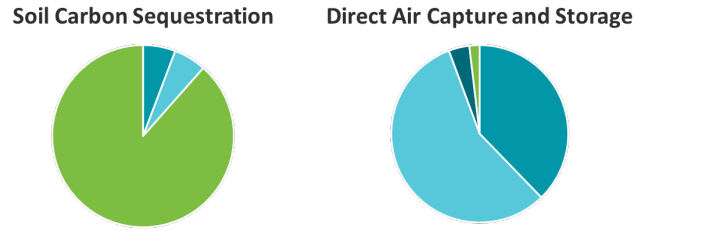
DOE Carbon Negative Shot

ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Carbon Negative™

Carbon Dioxide Removal (CDR) Pathways

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_2e 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



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

Ensure the first ton of removal is true, durable removal

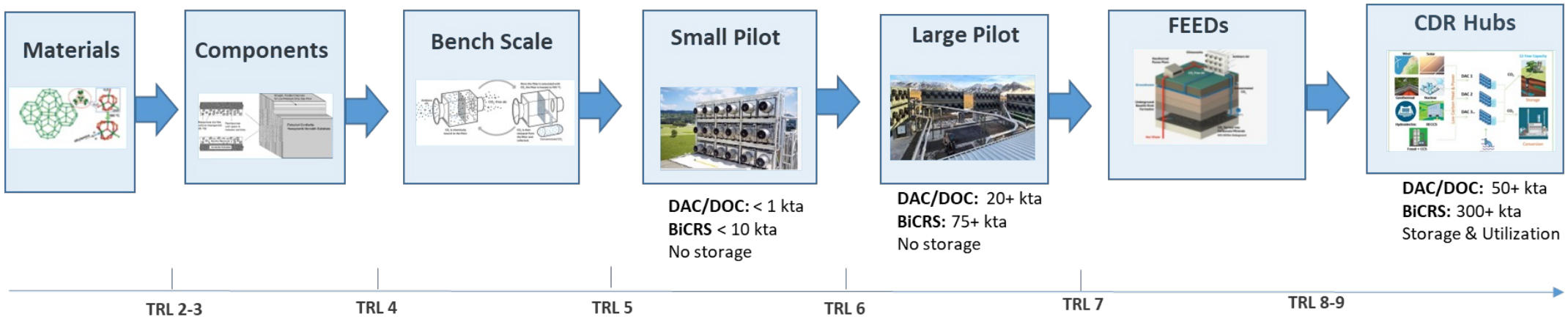
Ensure the last ton of removal is as affordable as it can be

https://www.energy.gov/fecm/carbon-negative-shot

CDR Portfolio within DOE

✓ FY23/24 Plans

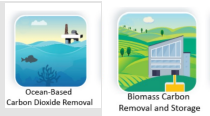
✓ Active Projects



BES/ARPA-E

FECM

EERE



OCED

Regional Direct Air Capture Hubs

Topic Area 1: Feasibility
Concept Studies

$40,875,131 total selected
Maximum award of $3,000,000 per project
14 awards
10 states
Up to 24 months to complete

Topic Area 2: Design
FEED Studies

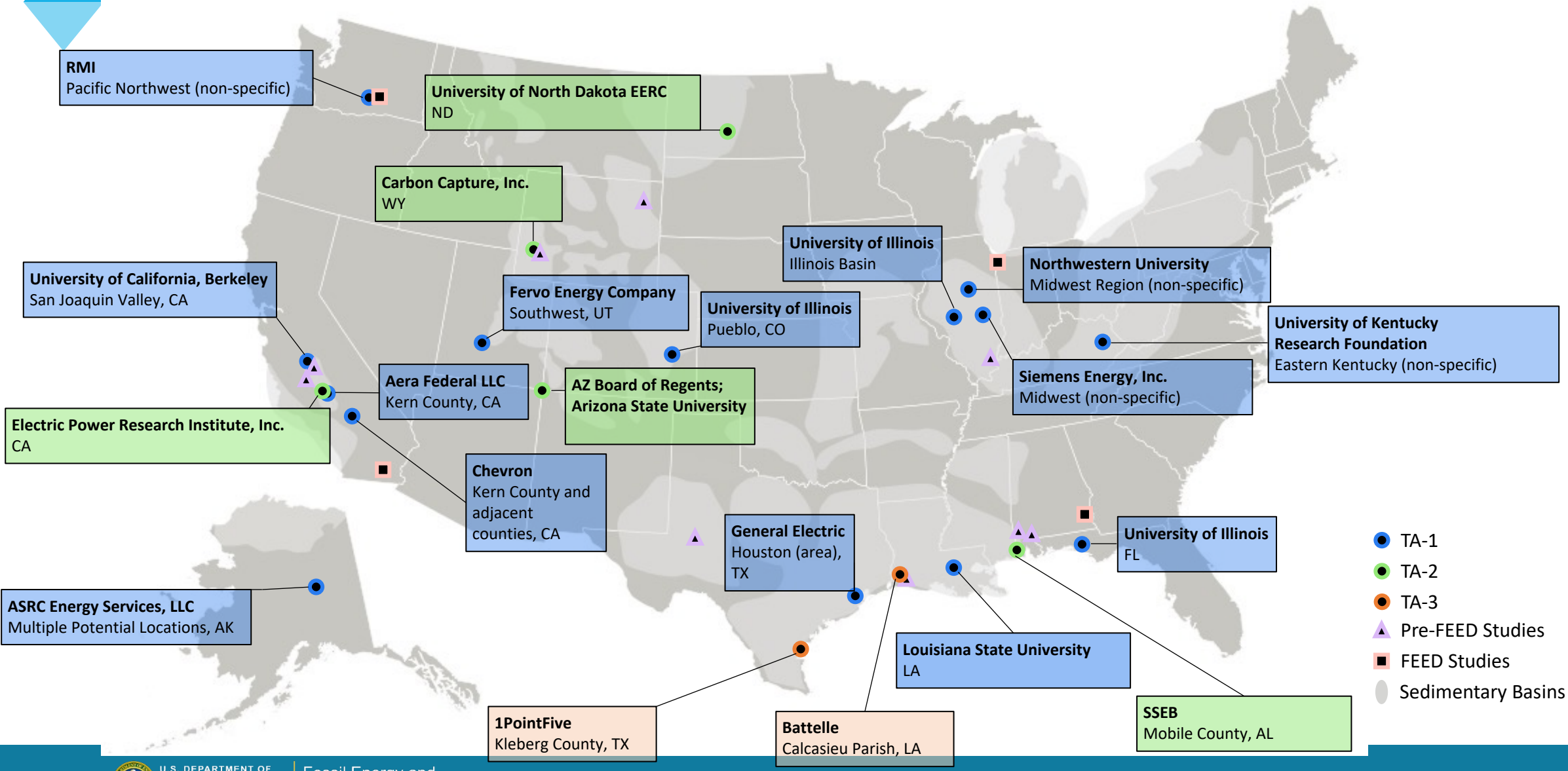
$58,658,012 total selected
Maximum award of $12,500,000 per project
5 awards
5 states
Up to 24 months to complete

Topic Area 3: Build
Full Hub Design, Construction, and Operation

Up to $1.2B
2 states
Up to 10 years to complete

- Meets industry at diversity of technology readiness levels → avoids tech lock in for early movers
- Supports a diversity of technologies and business models
- Launches community benefits conversations before detailed design
- Shows opportunity for DAC across geographies

TA-1, 2 & 3 Anticipated DAC Hub Location



Carbon Negative Shot Notice of Intent (DE-FOA-0003081)

Commercial DAC Prize
(Bipartisan Infrastructure Law funded)

Track 1:
Direct Air Capture (DAC) Pilot Prize

Supports next generation of transformational DAC technology at approximately 1-5ktCO2/year scale
$60M

Provides proof point to scale into DAC Hubs in the future

Track 2:
CDR Purchase Pilot

Direct Federal government CDR purchasing effort with $35M distributed over several prize phases.

CDR suppliers representing a suite of technologies consistent with the Carbon Negative Shot will compete for purchase agreements with DOE.

Small CDR Pilots and MRV funding
(Base appropriations funded)

CDR pilots – shows DOE's commitment to full suite of CDR approaches. Includes:

- Biomass carbon removal with storage
- Enhanced mineralization
- Multi-pathway CDR testbeds
- Marine CDR (both biotic and abiotic)

Additional MRV funding to support robust carbon crediting.

2023 CARBON MANAGEMENT RESEARCH PROJECT REVIEW MEETING | netl.doe.gov

U.S. poised for commercial liftoff

Pathways to Commercial Liftoff: Carbon Management

Pathways to Commercial Liftoff: Carbon Management (energy.gov)

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

Thank You!

Questions?

Contact Rory Jacobson, Senior Advisor
Rory.Jacobson@hq.doe.gov

Topic Area – 3, Regional DAC Hub Project Selections

Regional DAC Hub Projects are led by the Office of Clean Energy Demonstrations (OCED)
Two projects selected for negotiations

- **Project:** South Texas DAC Hub

- **Location:** Kleberg County, TX
- **DAC Hub Owner:** 1PointFive
- **Technology Provider:** Carbon Engineering Ltd.
- **CO_2 Removal:** Designed to capture up to 1 million metric tons of CO_2 annually
- **CO_2 Storage:** Saline geologic CO_2 storage site
- **CBP Highlights:** Creation of ~2,500 jobs in construction, operations, and maintenance with existing agreements for local hiring—including a target quota for local construction and operations; creation of a Citizen Advisory Board to ensure meaningful community engagement

- **Project:** Project Cypress

- **Location:** Calcasieu Parish, LA
- **DAC Hub Owner:** Battelle
- **Technology Providers:** Climeworks, Heirloom Carbon Technologies
- **CO_2 Removal:** Aims to capture more than 1 million metric tons of CO_2 annually
- **CO_2 Storage:** Deep saline aquifer, through an offtake agreement with Gulf Coast Sequestration
- **CBP Highlights:** Creation of ~2300 jobs, with a goal to hire workers formerly employed by the fossil fuel industry for 10% of the overall workforce; robust two-way community engagement towards developing a Community Benefits Plan

Overview of FECM DAC Activities

- **DAC R&D Portfolio**
  - 42 DAC projects (27 active and 15 inactive)
  - Project funding ranges from **~$1-5M**
  - Technology Readiness Levels (TRL) spanning from 3-6

- **DAC Pre-Commercial Prizes**
  - Energy Program for Innovation Clusters (EPIC) Prize: **$3.7M** for creative and impactful plans to support entrepreneurs and innovators and create meaningful community engagement
  - Technology Prize: **$3.2M** and **$800K in technical assistance vouchers** for identifying a critical need in the DAC industry, developing a solution to address this gap, and testing the idea

- **DAC Hubs**
  - **$3.5B** for the development of 4 regional DAC hubs which have 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

- **Mission Innovation CDR Launchpad**
  - Coalition of governments who have committed to:
    1. Building at least one 1,000+ tCO_2/yr CDR project by 2025 and promoting knowledge sharing efforts
    2. Collectively contributing at least **$100M** by 2025 to support CDR pilots and demonstrations
    3. Providing in-kind support to increase credibility and demand for CDR solutions

- **Technology Commercialization Fund MRV* Lab Call**
  - **$15M** to enable commercialization of CDR solutions
  - Specific areas involve measuring carbon, quantifying net-carbon removed, increasing transparency and developing best practices for protocols and processes

- **Commercial DAC Prize**
  - Establish a **$100M** prize competition to scale DAC and CDR pathways with permanent storage.

US International Engagement Activities

Bilateral:

- *R&D complementarities:* Canada, Norway, Japan, U.K., Australia, UAE, KSA, and more
- *Enabling activities:* Kenya, Nigeria, Brazil, India, Malaysia, Indonesia, and more

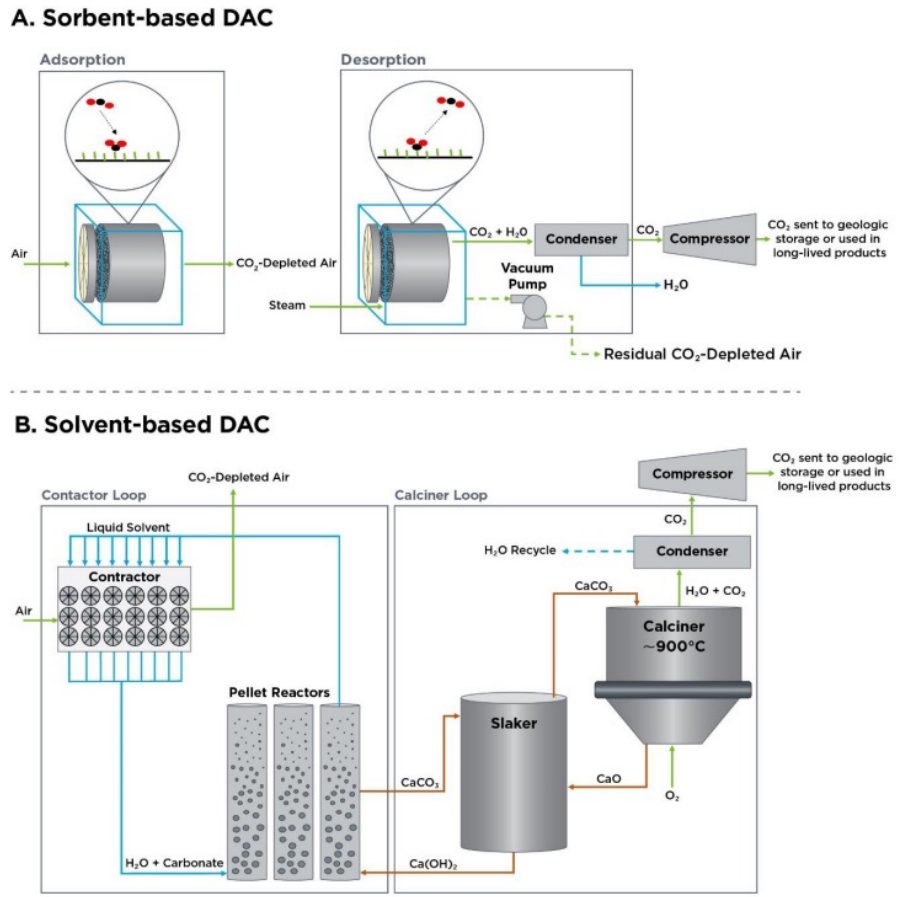
Multilateral:

- *Information sharing and catalyzing actions:* Clean Energy Ministerial CCUS Initiative, Mission Innovation CDR mission, CDR Launchpad, G7, G20, IEA GHG Programme, and more
- *Joint R&D collaborations:* Accelerating CCUS Technologies (ACT) and Clean Energy Transition Partnership (CETP)
- *Finance:* Development banks
- *Capacity building*: International organizations

Direct Air Capture (DAC) with Secure Storage

Direct air capture refers to any process or technology that captures CO_2 directly from ambient air using a CO_2 capture medium that is regenerated for re-use. The captured CO_2 is then securely stored geologically or in long-lived products, in a process known as direct air capture with storage.

R. Service, science.org, **2018**.



Carbon Dioxide Removal Mission Innovation, **2022**.