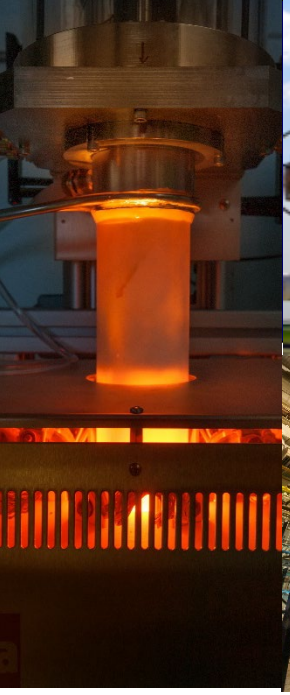
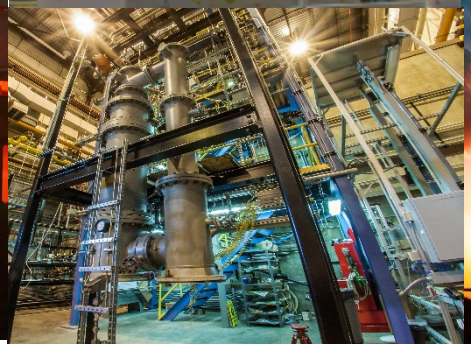
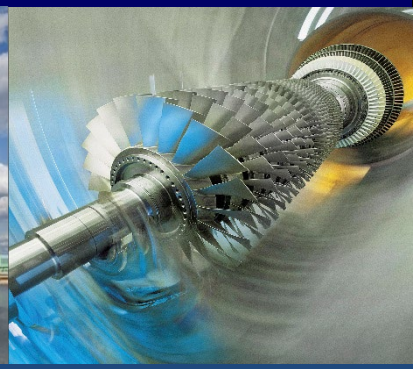




U.S. DEPARTMENT OF ENERGY | Office of Fossil Energy

Negative Emissions Technologies

February 7, 2020
Southern States Energy Board

Angelos Kokkinos
Associate Deputy Assistant Secretary
Office of Clean Coal & Carbon Management

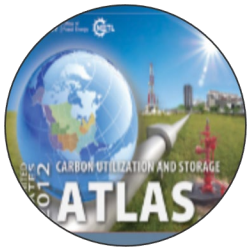
THE US: THE GLOBAL LEADER ON CCUS RESEARCH, DEVELOPMENT, AND DEPLOYMENT

- **40+ year history of CO_2 utilization for enhanced oil recovery (EOR)**
- **Over 600 million tons of associated storage with EOR**
- **Over 4,000 miles of CO_2 pipelines in the United States**
- **Strong efforts in developing the human capital and enablers for CCUS deployment**
  - Broad R&D program engaging Private Industry, Universities, National Laboratories, small business, and the financial community.
- **Has successfully invested in major CCUS demonstrations**
- **Focused on the full CCUS life cycle of carbon and hydrocarbons from extraction**
- **Leading one of the most globally recognized and successful RD&D programs on CCUS….**
- **…And leveraging this technology, science, and knowledge with other agencies for sound policy development.**

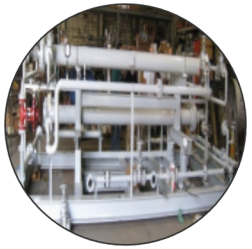
DOE's CCUS RD&D Program is a key component for many negative emissions technologies (NETs).

FEDERAL INVESTMENT

Carbon Utilization
R&D and technologies to convert CO_2 to value-added products

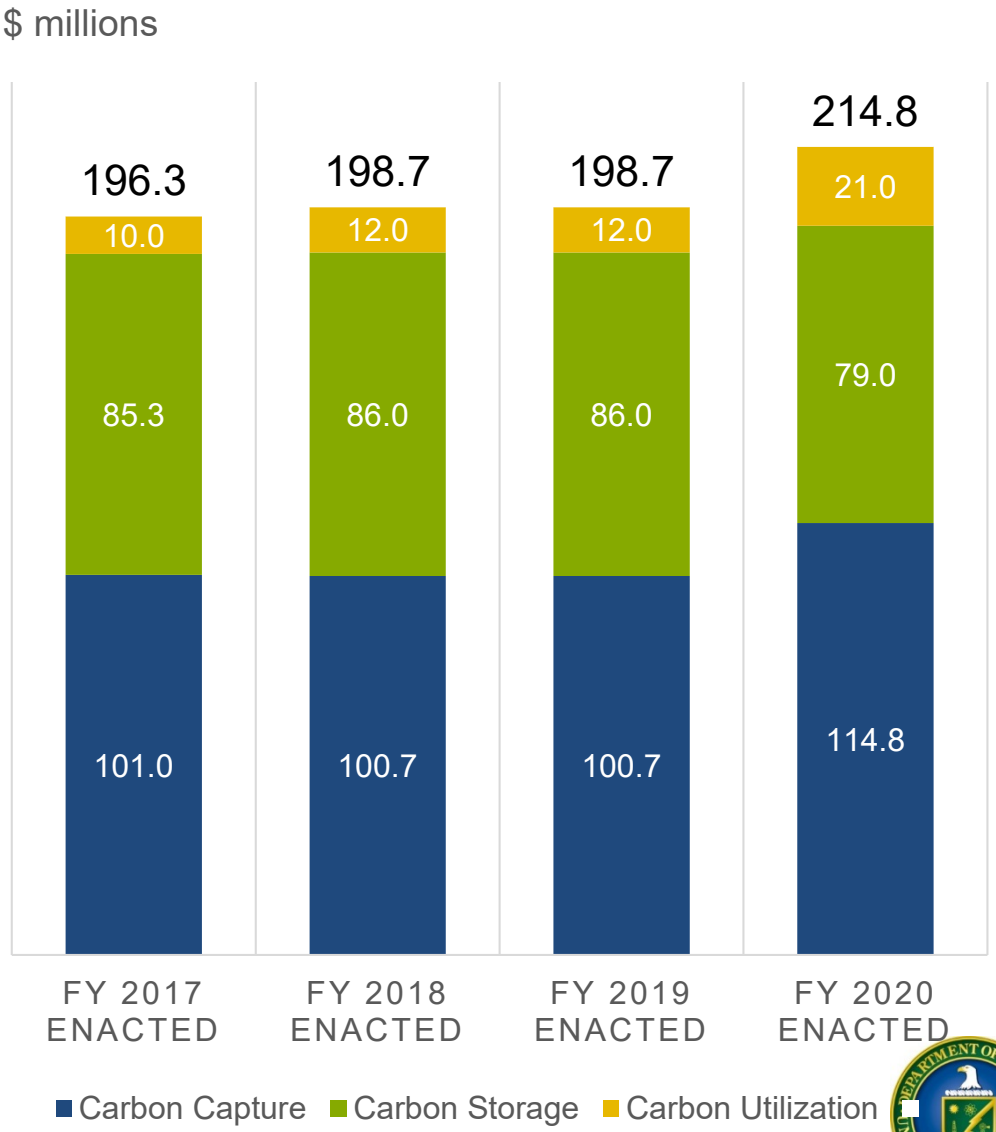


Carbon Storage
Safe, cost- effective, and permanent geologic storage of CO_2



Carbon Capture
R&D and scale-up technologies for capturing CO_2 from new and existing industrial and power plants

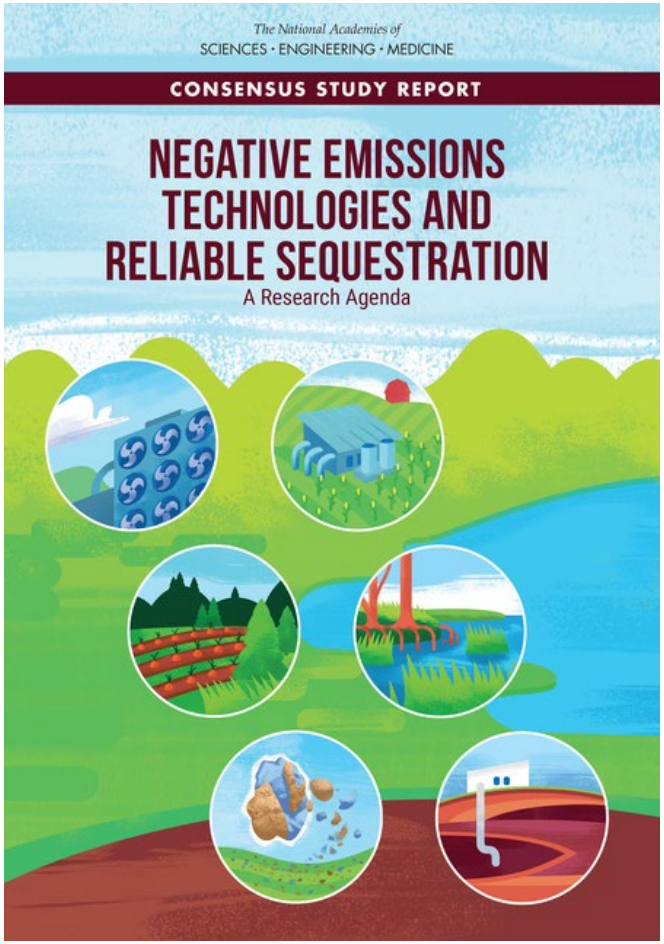
- $4B invested in CCUS demonstration projects
- $1B invested in carbon capture technologies



NATIONAL ACADEMY OF SCIENCES (NAS) REPORT ON NETs

- **Co-funded by DOE-FE, EPA, NOAA, USGS, and private funders.**
- **Defined six areas of NETs:**
  - Coastal Blue Carbon
  - Terrestrial Carbon Removal and Sequestration
  - Bioenergy with Carbon Capture and Sequestration (BECCS)
  - Direct Air Capture (DAC)
  - Carbon Mineralization of CO_2
  - Sequestration of Supercritical CO_2 in Deep Sedimentary Geological Formations

FE-related efforts



NETs TECHNOLOGIES COMPLEMENT AND BUILD UPON ON-GOING FE EFFORTS

- **BECCS**
  - Conversion of biomass to power, liquid fuels, chemicals, or heat with CCS. Key building block is CCS component – already in FE portfolio.
  - Co-feeding of coal-biomass with CCS – take advantage of economies of scale while also achieving negative emissions
- **ADM project, while not negative emissions, serves as example of potential BECCS technology**

ADM Ethanol Facility (Decatur, IL) – operations began in 2017

- Built and operated by Archer Daniels Midland (ADM) at its existing biofuel plant
- CO_2 from **ethanol biofuels production** captured and stored in **deep saline reservoir**
- **First-ever CCS project** to use new U.S. Environmental Protection Agency (EPA) Underground Injection **Class VI well permit,** specifically for CO_2 storage
- **1.5 million metric tons of CO_2 stored**, since April 2017

DAC PROCESSES SIMILAR TO POINT SOURCE CAPTURE

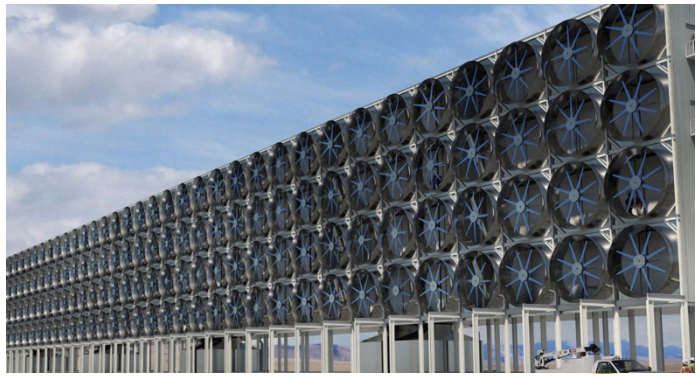
Similar processes used for point source capture are used for DAC

- *Chemical Solvents – Amine and carbonate based*
- *Chemical and Physical Sorbents – amine functionalized, zeolites, carbon based*
- *Membranes – Polymeric or facilitated transport*
- *Cryogenic systems – incidental air capture with Nitrogen production*

Energy Penalty – *Both require heat or electricity for regeneration*

Compression required for end use – *Electricity demand*

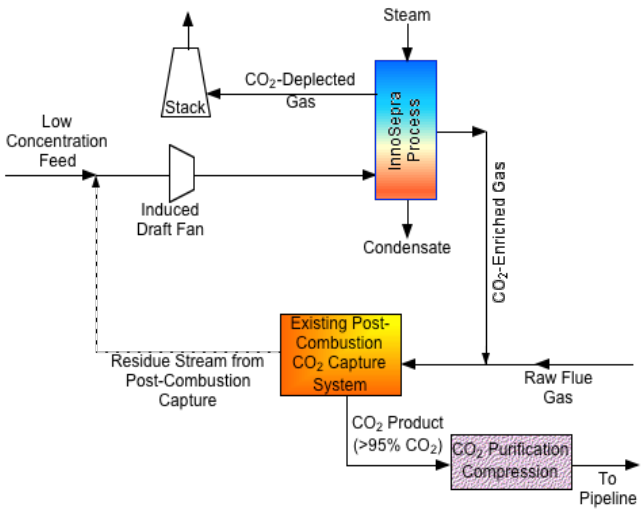
Conversion – *Same processes to convert to products*



DAC/DILUTE SOURCE CAPTURE: FE/NETL PROJECTS

InnoSepra LLC

Physical Sorbent
(1-1.5% CO_2 Concentration)



Fixed-bed laboratory unit for testing structured sorbents

The Ohio State University

Membranes
(<1% CO_2 concentration)

Continuous membrane fabrication machine at OSU

https://www.netl.doe.gov/research/coal/project-information/proj?k=FE0026919

Carbon Engineering

Wet scrubbing air contactor
(400 ppm Direct Air Capture)

Carbon Engineering's research pilot facility in Squamish, BC

CARBON MINERALIZATION OF CO_2

- **NAS defines as both surface and subsurface**
- **Surface/Ex situ: reactive minerals (e.g., exposed rocks, mine tailings and alkaline industrial wastes)**
  - DOE-FE and NETL early research on utilization of magnesium silicate and calcium silicate minerals in surface processes
- **Subsurface:**
  - Regional Carbon Sequestration Partnerships – Carbon Storage Atlas - characterization efforts
  - Projects with PNNL, Yale, University of Washington, Virginia Tech on potential subsurface response/interactions of mafic/ultramafic rocks with CO_2
  - Big Sky RCSP – 1,000 ton injection project in Wallula, WA
  - CarbFIX project in Iceland – Columbia University
  - CarbonSAFE Phase 1 Project – Cascadia basin in offshore Washington state and British Columbia – Columbia University

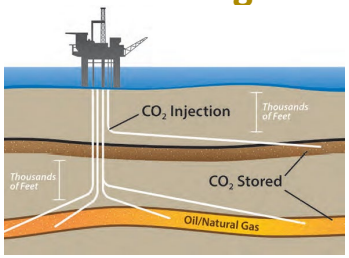
CARBON STORAGE R&D PROGRAM

IMPROVING AND OPTIMIZING PERFORMANCE

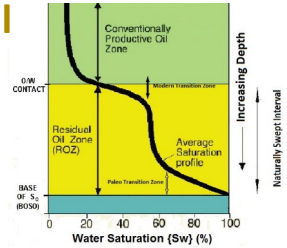
Regional Carbon Sequestration Partnerships (RCSPs)

CarbonSAFE

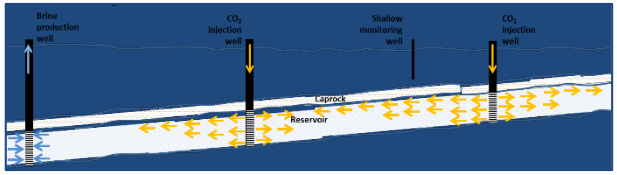
Offshore Storage



Unconventional EOR



Brine Extraction Storage Tests (BEST)



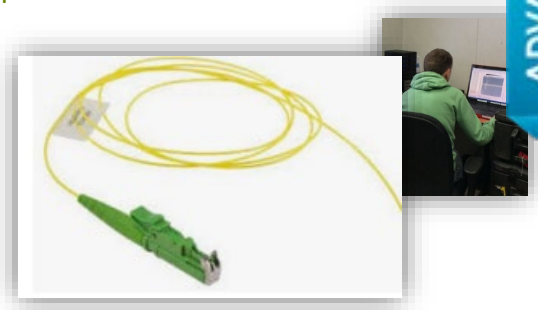
CARBON STORAGE PROGRAM

ADVANCED STORAGE R&D

- Plume Detection and Storage Efficiency
- Secure Storage
- Subsurface Stress
- Wellbore Integrity
- Risk Assessment

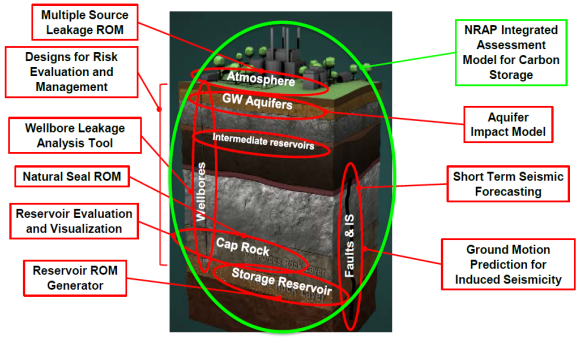
STORAGE INFRASTRUCTURE

Advancing monitoring and measurement tools: improving characterization and reducing the uncertainty about the CO_2 and pressure fronts.



Fiber Optic Distributed Acoustic Sensing (DAS)

National Risk Assessment Partnership (NRAP) is developing toolsets to reduce uncertainty and quantify potential impacts related to release of CO_2 and induced seismicity



DOE NETs EFFORTS IN FY2020+

- **NETs FY2020 Funding Opportunities**
  - **Direct Air Capture –** Materials and Processes
  - **Coal-biomass with CCS for negative emissions (BECCS)**
  - **Pre-feasibility studies for FE & biomass industrial facilities**
  - **University Coal Fossil Energy Research on Materials –** novel DAC materials – (FY2019)
  - **SBIR -** novel DAC materials – 2020

- **Continuation of Carbon Storage R&D portfolio activities**

- **CO_2 Mineralization**
  - Opportunities through new regional initiative and targeted national lab efforts

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Questions?

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