



U.S. DEPARTMENT OF
ENERGY

Fossil Energy and
Carbon Management

Opportunities for CCUS in the Natural Gas Sector

VIRTUAL INFORMATIONAL WORKSHOP ON RESPONSIBLE AND SUSTAINABLE
NATURAL GAS: CHALLENGES AND OPPORTUNITIES IN AFRICA

September 15, 2021



Legend:

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

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| 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 Rare Earth Elements, ** Critical Heavy REE, *** Included with rare earth elements



CCUS is not new – concepts have been deployed for decades

Carbon Capture

- Technologies available for gas separations for many decades

US Efforts

- Nearly 50-year history of CO₂ used for enhanced oil recovery (EOR)
- 20+year RDD&D Program
- Regulatory Framework mostly in place
- Financial Incentives (Federal and State)

Global Projects (not inclusive)

- Sleipner Project-Norway
- Lula-Brazil
- Quest-Canada

CCUS has applicability throughout natural gas supply chain



Major CCS Demonstration Projects in the US – First Generation Technologies

Air Products Facility (Port Arthur, TX) - 2013



- Built and operated by Air Products and Chemicals Inc. and located at Valero Oil Refinery in Port Arthur, TX
- State-of-the-art system to capture the CO₂ emitted from two large steam methane reformers
- 7.1 million metric tons of CO₂ captured and transported via pipeline to oil fields in eastern Texas for enhanced oil recovery (EOR) since March 2013

Petra Nova CCS (Thompsons, TX) - 2017



- Joint venture by NRG Energy, Inc. and JX Nippon Oil and Gas Exploration
- Demonstrate the Mitsubishi Heavy Industries CO₂ capture technology ability to capture 90% of the CO₂ emitted from a 240-megawatt flue gas stream. (designed to capture/store 1.4 million tonnes of CO₂ per year)
- Nearly 3.8 million metric tons of CO₂ used for EOR in West Ranch Oil Field.
- Successfully completed DOE project objectives. Oil prices resulting in indefinite suspension of operations.

ADM Ethanol Facility (Decatur, IL) - 2017



- Built and operated by Archer Daniels Midland (ADM) at its existing biofuel plant
- CO₂ 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 CO₂ storage
- 2.3 million metric tons of CO₂ stored, since April 2017



Capture Program FEED Studies and Storage Program Field Initiatives

Capture Program FEED Studies

- Coal
- Natural Gas

Regional Initiative Projects

Membrane Technology and Research, Inc.
Basic Electric Dry Fork Station, WY

Minnkota Power Cooperative, Inc.
Milton R. Young Unit 2, ND

Ion Clean Energy Systems, Nebraska Public Power District, Gerald Gentleman Station, NE

Electric Power Research Institute, Elk Hills Power Plant, CA

Enchant Energy, LLC
San Juan Generation Station, NM

Carbon Utilization and Storage Partnership

PCOR Initiative

Midwest Regional Carbon Initiative

SECARB-USA

Board of Trustees for the University of Illinois
Prairie State Generating Company's Energy, IL

Southern Company Services, Inc.
Plant Daniel 3&4, MS

Bechtel National, Inc., Panda Power Funds, TX

University of Texas at Austin, Golden Spread Electric Cooperative
Mustang, TX

CarbonSAFE Phase III Projects

- North Dakota CarbonSAFE Phase III: Site Characterization and Permitting (UNDEERC)
- Wyoming CarbonSAFE: Accelerating CCUS at Dry Fork Power Station (UofW)
- Illinois Storage Corridor (Univ. of Illinois)
- Establishing an Early CO2 Storage Complex in Kemper County, Mississippi: Project ECO2S (SSEB)
- San Juan Basin CarbonSAFE Phase III: Ensuring Safe Subsurface Storage of CO2 in Saline Reservoirs



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Industrial Capture Pre-Feasibility Studies

| Prime Performer | Project Title | Location |
|---|--|-------------------|
| Praxair, Inc. | Engineering Design of a Linde-BASF Advanced Post-Combustion CO2 Capture Technology at a Linde Steam Methane Reforming H2 Plant | Convent, LA |
| ArcelorMittal USA, Inc. | Enabling Production of Low Carbon Emissions Steel through CO2 Capture from Blast Furnace (BF) Gases | Burns Harbor, IN |
| University of North Dakota Energy and Environmental Research Center (UNDEERC) | Initial Engineering and Design for CO2 Capture from Ethanol Facilities | Richardton, ND |
| Membrane Technology and Research, Inc. | Engineering Design of a Polaris Membrane CO2 Capture System at a Cement Plant | New Braunfels, TX |
| Electricore, Inc. | LH CO2MENT Colorado Project | Florence, CO |



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Carbon Capture: Multiple Technology Pathways and Multiple Areas of Improvement

Lab-Scale Unit

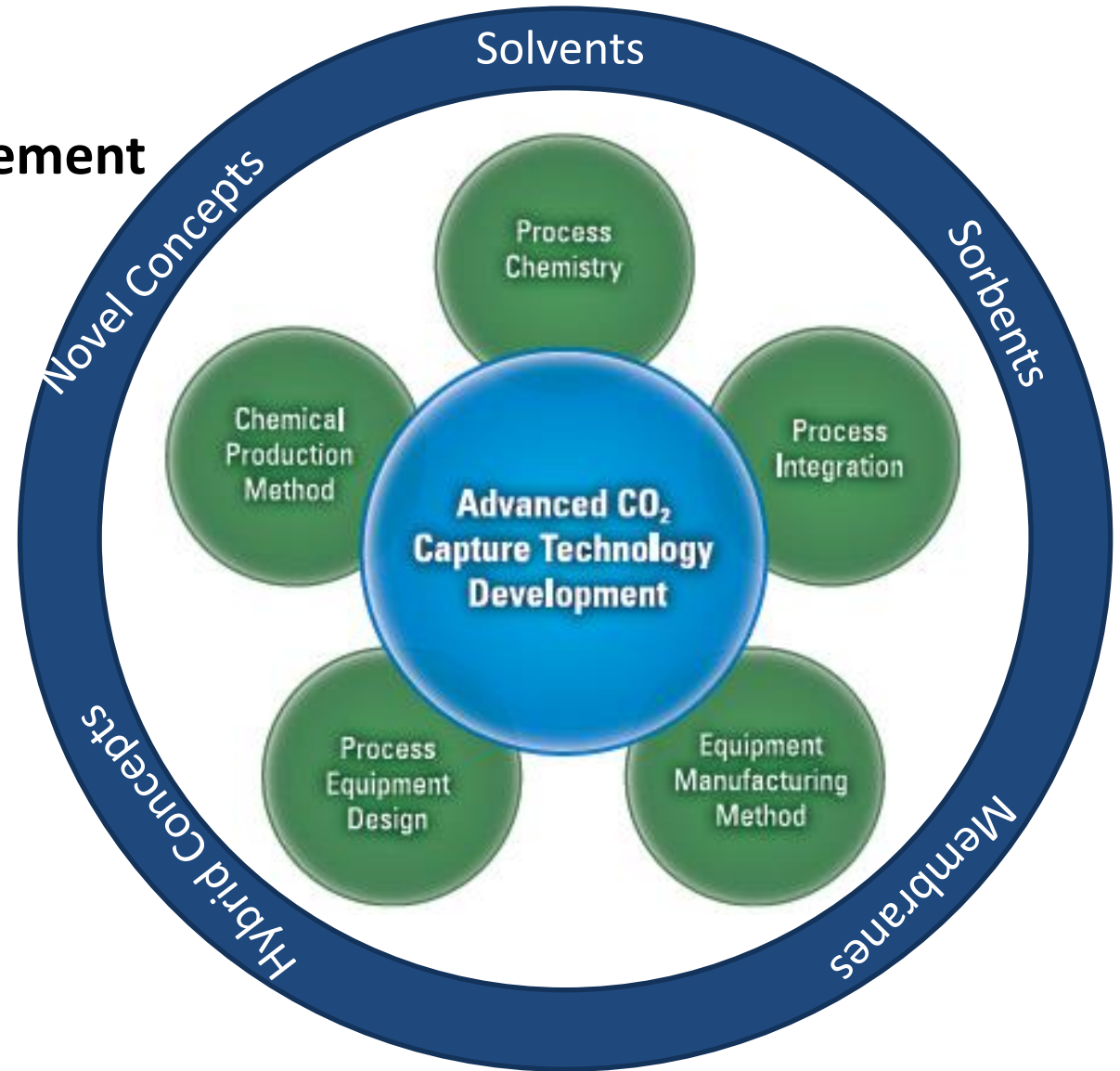


Bench-Scale Unit



Small Pilot-Scale Unit

National Carbon Capture Center



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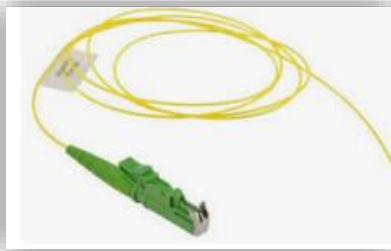
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Carbon Storage Program: Improving and Optimizing Performance

Regional Carbon Sequestration Partnerships (RCSPs)

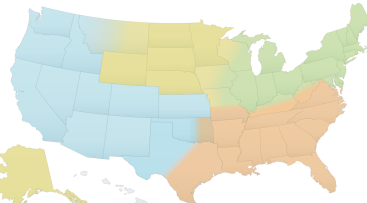


Advancing monitoring and measurement tools: improving characterization and reducing the uncertainty about the CO₂ and pressure fronts.



Fiber Optic Distributed Acoustic Sensing (DAS)

Regional Deployment Initiative



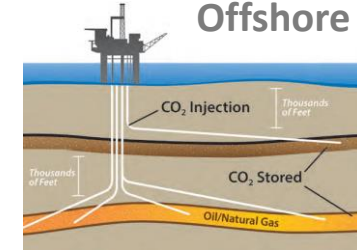
CarbonSAFE



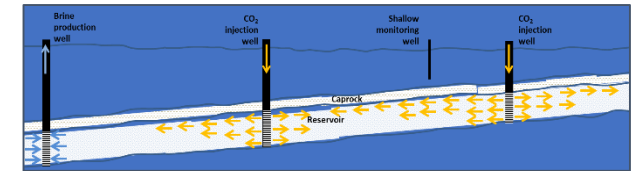
CARBON STORAGE PROGRAM



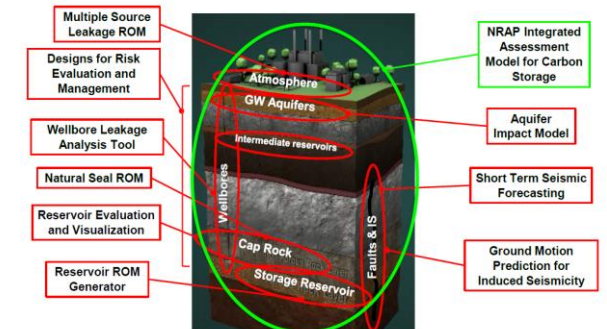
Offshore Storage



Brine Extraction Storage Tests (BEST)



National Risk Assessment Partnership (NRAP) is developing toolsets to reduce uncertainty and quantify potential impacts related to release of CO₂ and induced seismicity

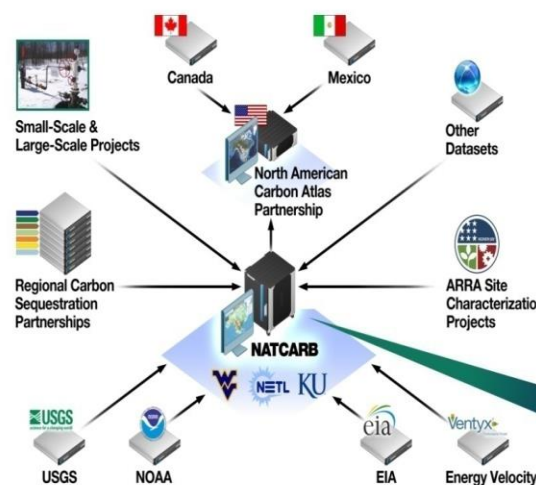
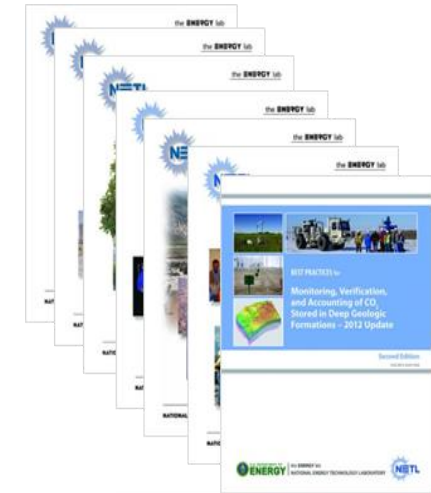
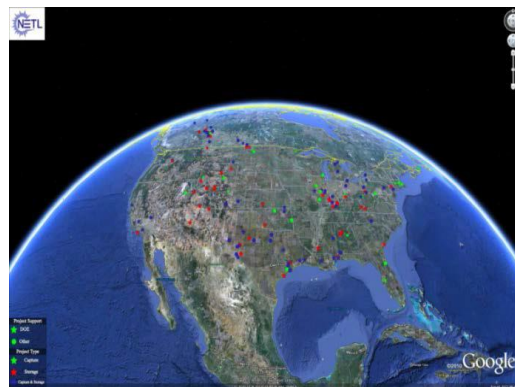


Knowledge Sharing Products and Tools and Capabilities



<https://netl.doe.gov/coal/carbon-storage/strategic-program-support/natcarb-atlas>

Worldwide CCS Project Database



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For more information



www.energy.gov/fe



facebook.com/FossilEnergy



<https://www.netl.doe.gov>



twitter.com/fossilenergygov

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Questions?



Legend:

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

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| 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 RARE Light REE, UNCE Heavy REE, ** Included with rare earth elements

