



The U.S. Department of Energy's (DOE) Carbon Capture, Utilization, and Storage (CCUS) research and development (R&D) program advances efforts to reduce the cost of carbon dioxide (CO<sub>2</sub>) capture; discover ways to utilize CO<sub>2</sub>; and safely and securely store captured CO<sub>2</sub> in geologic formations. The technologies developed and pilot-scale tests conducted through these programs will have applicability to power generation and industrial sources, including cement, steel, refining, hydrogen, and ethanol production. The technologies will also be used to directly remove CO<sub>2</sub> from the atmosphere. Through these CCUS R&D efforts, DOE is working with its domestic and international partners to enable CCUS as a viable carbon management option for reducing CO<sub>2</sub> emissions on a commercial scale.

## Major R&D Program Components

### Carbon Capture Program

The Carbon Capture program focuses on reducing the cost of capture and the associated energy penalty. The program develops post-combustion, pre-combustion, and direct air capture technologies. The strategy for the program is to conduct laboratory-, bench-, and pilot-scale testing of advanced technologies that are applicable for multiple commercial sectors. With a focus on advanced solvents, solid sorbents, membranes, hybrid systems, and other innovative technologies (e.g., cryogenic capture systems), the program has the potential to reduce the cost of carbon capture by 33 percent compared to the cost of today's technology for power plants, to \$30/tonne.



*Image of the Small Pilot Test Unit at the NCCC.*

Additionally, the Carbon Capture program utilizes a comprehensive approach that leverages not only chemistry and materials science, but also process engineering and design, high-performance computing, and advanced manufacturing to innovate and create novel capture technologies and systems.

### Carbon Utilization Program

The Carbon Utilization program develops technologies that can convert carbon-containing feedstocks, such as CO<sub>2</sub>, into higher value products including chemicals, plastics, fuels, and building materials (e.g., cement and

aggregate). CO<sub>2</sub> has a long history of use in commercial applications and many products used every day either utilize or consume CO<sub>2</sub>. For example, CO<sub>2</sub> is used in the production of urea as a fertilizer and in fire suppression equipment, beverage carbonation, municipal water treatment, and precision cleaning of electronics. Additionally, one of the more common and widespread uses of CO<sub>2</sub> has been for enhanced oil recovery (EOR), where CO<sub>2</sub> is injected in oil-bearing rocks to help mobilize the oil and make it easier to produce.

The Carbon Utilization program is also researching and developing technologies, systems, and strategies to advance novel mineralization, biological, physical, and chemical pathways that can convert CO<sub>2</sub> into value-added products, while also creating a net reduction of CO<sub>2</sub> emissions. This research focuses on lowering cost and energy barriers to make these processes more economic, thus creating an additional value stream from CO<sub>2</sub>. In addition to the direct economic benefits of converting CO<sub>2</sub> into products, another benefit is reducing the amount of CO<sub>2</sub> that needs to be stored, which makes carbon storage less expensive by requiring fewer wells and less monitoring equipment.

### Carbon Storage Program

The Carbon Storage program focuses on developing technologies and protocols for the secure geologic storage of captured CO<sub>2</sub>. Captured CO<sub>2</sub> can be stored either onshore or offshore—in deep saline formations, coal and shale seams, and basalts—or injected and stored as part of EOR operations. The program conducts research and field activities to improve DOE's understanding of CO<sub>2</sub> injection, fluid flow and pressure migration and

geochemical impacts in a variety of geologic formations. The overarching goal of the research is to help lower the cost and improve the operational efficiency of carbon storage projects.

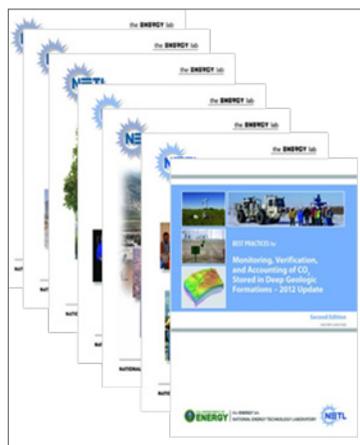
The program conducts activities in the following two areas:

1. *Storage Infrastructure R&D*: Identifies storage resources across various geologic environments both onshore and offshore; evaluates monitoring technologies and operational methods at the field scale to understand their impact in ensuring successful carbon storage operations; and validates modeling and simulation tools using field and operational data.
2. *Advanced Storage R&D*: Develops innovative and transformational storage-monitoring, simulation, and risk-assessment/management technologies and advanced wellbore technologies to safely and cost-effectively manage the injection and associated storage of CO<sub>2</sub> in onshore and offshore geologic reservoirs.

## Major Accomplishments

The CCUS R&D program has several important accomplishments in collaboration with its many partners. For instance, the National Carbon Capture Center (NCCC) located in Wilsonville, Alabama has completed over 110,000 test hours of 60 advanced carbon capture technologies. Operated by Southern Company Services, the facility has the capability to test post-combustion carbon capture technologies from the neighboring coal-fired power station using the flue gas of that power station.

NCCC has been in operation for over 10 years and can test multiple technologies at the same time and various scales, from 0.05 MWe (~1 ton of CO<sub>2</sub> per day) up to 3 MWe (~60 tons of CO<sub>2</sub> per day). The facility recently installed a natural gas-fired system that will allow for testing of technologies under coal-fired flue gas and natural gas-fired flue gas. The facility also has the capability to test carbon utilization technologies.



DOE's best practice manuals for carbon storage.

Recognized globally as an important CCUS initiative, DOE's Regional Carbon Sequestration Partnerships (RCSPs) have been instrumental in developing the infrastructure, tools, and capabilities to help facilitate widespread deployment of CCUS in the United States.

Initiated in 2003, the RCSPs consist of three phases: characterization, validation, and development. These projects have injected over 10 million metric tons of CO<sub>2</sub> for secured storage and have helped engage regional, state, and local stakeholders. They have also established regional baselines for sources and sinks, monitoring and verification protocols, and validated technologies. Perhaps one of the greatest takeaways of this effort has been the amount of data and information that is being made available to the public through the National Energy Technology Laboratory's Energy Data eXchange (EDX) and the release of best practice manuals and the fifth edition of the *Carbon Storage Atlas*.

For additional information about CCUS, please click [here](#), visit [energy.gov/fe/science-innovation/office-clean-coal-and-carbon-management/carbon-capture-utilization-and-storage](https://energy.gov/fe/science-innovation/office-clean-coal-and-carbon-management/carbon-capture-utilization-and-storage), or contact the following DOE personnel:

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