



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 (CO₂) capture; discover ways to utilize CO₂; and safely and securely store captured CO₂ 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, and ethanol production. The technologies will also be used to directly remove CO₂ 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 CO₂ 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 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 50 percent to \$30/tonne compared to today's technology for power plants.



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 CO₂, into higher value products including chemicals, plastics, fuels, and building materials (e.g., cement and

aggregate). CO₂ has a long history of use in commercial applications and many of the products used every day either utilize or consume CO₂. For example, CO₂ has been used in: the production of urea as a fertilizer, fire suppression equipment, beverage carbonation, and precision cleaning of electronics. Additionally, one of the more common and largest uses of CO₂ has been for enhanced oil recovery (EOR), where CO₂ 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 CO₂ into value-added products, while also resulting in a net reduction of CO₂ emissions. This research focuses on lowering the cost and energy barriers to make these processes more economic, which subsequently creates an additional value stream from CO₂. In addition to the direct economic benefits of converting CO₂ into products, another benefit is reducing the amount of CO₂ 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 CO₂. Captured CO₂ 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 CO₂ 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 risks and 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 CO₂ in onshore and offshore geologic reservoirs.

Major Accomplishments

The CCUS R&D program has had several important accomplishments in collaboration with its many partners. For instance, the National Carbon Capture Center (NCCC) located in Wilsonville, Alabama has completed over 100,000 test hours of 50 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 in a real-world flue gas.

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 CO₂ per day) up to 3 MWe (~60 tons of CO₂ per day). Currently, the facility is installing a natural gas-fired system, which will allow for testing of technologies under coal-fired flue gas conditions, as well as natural gas-fired conditions. The facility also has the capability to test carbon utilization technologies.



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 consisted of three phases: characterization, validation, and development. These projects have injected over 10 million metric tons of CO₂ 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 fifth edition of the *Carbon Storage Atlas*.

For additional information about CCUS, please click [here](#) or contact the following DOE personnel:

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