Federal Energy RD&D: Carbon Storage and Utilization

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The Carbon Storage and Utilization programs are focused on the development of technologies for the safe use and permanent storage of captured carbon dioxide (CO₂). The storage program focuses on developing the technologies and infrastructure necessary to store captured CO₂ safely in deep saline formations or oil and natural gas reservoirs.¹ The carbon use and reuse program focuses on recycling captured CO₂ for use in valuable products, such as chemicals, fuels, and building materials.

Figure 1: The Energy Act of 2020 authorizes a 150 percent increase in carbon storage and use in FY 2022.²

What’s at Stake

Limiting global climate change to less than 2°C of warming may require between 20 billion and 60 billion tons of CO₂ to be captured and sequestered every year by the end of the century.³ If so, carbon management will become one of the world’s largest industries, equivalent in scale to food production (~15 billion tons), construction materials (>60 billion tons), and fossil fuel production (~20 billion tons).⁴

Preliminary research suggests the United States has enough subsurface capacity to permanently sequester 1.71 trillion metric tons of CO₂, which is the equivalent of 950 years of carbon emissions from power plants at 2016 levels.⁵ However, additional cost reductions, validation, safety testing, and mitigation research are necessary to realize this capacity. While the size of many subsurface storage reservoirs has already been initially characterized, detailed site-specific work is required to confirm their potential. Research and development (R&D) are also needed for tools to map and simulate below-ground fractures and faults with a high degree of resolution and fidelity, devise wellbore materials that can better resist corrosion by CO₂-saturated brine, and improve the ability to monitor and mitigate the risk of induced seismicity from the injection of
CO₂ underground. And large-scale, long-term demonstration projects are necessary to ensure captured CO₂ is safely and permanently stored.

In April 2017, the Illinois Industrial Carbon Capture and Storage project—funded jointly by the Department of Energy (DOE) and private investors—began capturing CO₂ from an ethanol production facility and storing it underground in a saline reservoir at a rate of 1 million metric tons of CO₂ per year. This large, first-of-a-kind demonstration project is testing and validating technologies while concurrently endeavoring to reduce future costs. In 2018, as part of its Carbon Storage Assurance Facility Enterprise (CarbonSAFE) initiative, DOE selected three additional cost-shared research, development, and demonstration (RD&D) projects to identify sites that could store more than 50 million metric tons of CO₂. This effort must be expanded. The National Academies of Sciences, Engineering, and Medicine (NASEM) recommends that DOE work with the Department of Interior and U.S. Geological Survey to “[c]haracterize sustained CO₂ injection rates that can be achieved across each of the major CO₂ sequestration basins and identify by 2030 high injection rate locations suitable for injection of approximately 250 million metric tons of CO₂ per year.”

Carbon utilization—turning CO₂ from waste into a product of value—provides another option for managing CO₂ and may be a glide path to incenting greater carbon capture. Most potential uses for captured carbon, such as carbon nanotubes and synthetic hydrocarbon fuels, are far from commercialized and require further RD&D in order to bring costs down. In 2019, the National Academies developed a broad innovation agenda for chemical and biological conversion of CO₂ into fuels and chemicals, but funding at DOE has been insufficient to address the full suite of RD&D that needs to be identified by the study.

The vast majority of captured carbon would ultimately need to be sequestered in geologic reservoirs. Even if carbon use expands substantially, potential markets to absorb CO₂ will be much smaller than the total carbon capture, utilization, and sequestration (CCUS) anticipated in a net-zero emissions world. For example, if CO₂ were used as the source of all carbon in the global annual production of plastics (311 million metric tons per year in 2014), it would consume about 0.8 gigatons of CO₂ per year, far less than 10 percent of the anticipated total previously referenced.

The Energy Act of 2020 provides the first reauthorization of DOE’s carbon use and storage program in over a decade. The bill directs DOE to establish a large-scale carbon sequestration demonstration program and requires DOE to produce a roadmap for carbon storage RD&D activities through 2025 to reduce economic and policy barriers to commercial carbon storage. The bill also expands DOE’s carbon utilization RD&D program and directs DOE to establish a two-year demonstration program in each of the major coal-producing regions to accelerate commercial deployment of coal-carbon products—such as carbon fiber derived from coal—that result in no significant emissions of CO₂ or other pollutants. The bill directs DOE to establish a national Carbon Utilization Research Center to support early-stage RD&D activities to convert CO₂ into valuable products and commodities.

Figure 1 shows historical DOE investment in carbon utilization and storage activities by subprogram, for FY 2016 through 2021, and the FY 2022 budget request. (Appropriations for carbon storage by subprogram were unspecified for FY 2021, and the topline number only is shown.) The orange line shows total authorized funding levels in the Energy Act of 2020 for FY
2021 through 2025, across all carbon storage and use activities. Authorizations across carbon storage and use are shown as light orange and blue bars. The blue line shows recommended R&D (only) funding levels from the *Energizing America* report (see box 1).

**Box 1: An Innovation Agenda for Carbon Storage and Use**

The *Energizing America* report coauthored by the Information Technology and Innovation Foundation (ITIF) and Columbia University’s Center on Global Energy Policy offers several recommendations to accelerate carbon storage and use innovation.  

- DOE should identify the funding levels needed to address the recommendations of the National Academies of Sciences, Engineering, and Medicine’s (NASEM) roadmap for advancing CO2 utilization technologies. Congress should provide sufficient funding to match the RD&D needs.  

- DOE should increase the ambition of its current carbon storage goal of 50 million metric tons of storage capacity characterized by 2026 and adopt the National Academies target of 250 million metric tons by 2030. DOE should develop a roadmap and funding levels to meet the new target, and Congress should provide sufficient levels of funding.  

- Congress and DOE should address CO2 infrastructure and regulatory barriers that deter investment in carbon capture. DOE should work with the Department of Transportation, U.S. Geological Survey, and other agencies to plan and assess the requirements for a national CO2 trunk pipeline network, characterize geologic storage reservoirs, and establish permitting rules.  

**Carbon Storage and Utilization RD&D Activities**

Funding for carbon storage and utilization RD&D is spread across four activities:

- **Storage Infrastructure R&D** focuses on geologic resource characterization and small- and large-scale field projects to demonstrate permanent geologic storage; validation of injection, simulation/risk assessment, and monitoring strategies; and assessment of the probability, and subsequent mitigation, of potential seismic events. Program activities include the CarbonSAFE initiative, which funds industry cost-shared RD&D projects to characterize and develop commercial-scale (more than 50 million metric tons of CO2) storage complexes by 2025; the Brine Extraction Storage Test, which advances strategies for managing subsurface pressure and fluid flow; and the seven Regional Carbon Sequestration Partnerships (RCSPs), which are currently testing large-scale CO2 injection and storage technologies.  

- **Advanced Storage R&D** is focused on validating storage monitoring, simulation, risk assessment, and advanced wellbore technologies to detect and mitigate wellbore issues. R&D activities include developing CO2-resistant construction materials and well-integrity technologies, plus technologies to detect and mitigate potential CO2 leakage pathways.
- **Sub-disciplinary Storage R&D** focuses on assessment and validation of subsurface models; support for the National Risk Assessment Partnership (NRAP), with a focus on storage risk tools; and development of the Energy Data Exchange (EDX) system, which supports data management and technology transfer. The budget request proposes merging the subprogram with Advanced Storage R&D.\(^{18}\)

- **Carbon Use & Reuse R&D** explores the beneficial reuse of CO\(_2\), including conversion into higher-value products such as chemicals, plastics, and building materials, and accelerated curing for cement. The primary objective is to lower the near-term costs of CCUS through the creation of value-added products via the conversion of CO\(_2\).

**Key Elements of the FY 2022 Budget Proposal\(^{19}\)**

The budget proposal seeks $155 million for carbon storage and utilization RD&D activities, a 52 percent boost from FY 2021 enacted levels. Some highlights include:

- **A 48 percent increase in Storage Infrastructure R&D**, including increased funding for the CarbonSAFE initiative to identify opportunities for onshore and offshore storage formations; and increased funding for the four Regional CCUS initiative projects.

- **A 104 percent increase in Advanced Storage R&D (which would be merged with Sub-disciplinary Storage R&D)**, to support storage options beyond sedimentary basins and continue to fund the Science-informed Machine learning to Accelerate Real-Time (SMART) Initiative that advances artificial intelligence and machine learning-based technologies to optimize storage operations.

- **A 65 percent increase in Carbon Use & Reuse R&D**, which will support the development of at least one carbon utilization integrated system.

**Further Reading**


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ENDNOTES


12. Ibid.


