# Fiscal Year 2026 Carbon Removal Research, Development, and Demonstration Priorities for the US Department of Energy and other related Agencies

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Carbon removal technologies are an emerging yet increasingly essential component of the US climate and energy strategy. To meet midcentury net-zero goals and address emissions that are otherwise difficult or impossible to eliminate, carbon removal must scale rapidly. However, carbon removal can't scale without deliberate, sustained public investment to drive down costs and accelerate deployment, just as has been done with wind, solar, and batteries.

Federal research, development, and deployment (RD&D) funding is the most powerful lever in bringing these technologies down the cost curve. Without it, we risk delayed climate progress, losing leadership in global technology innovation, and missing out on a generational economic opportunity. Smart RD&D investments today will unlock cost-effective, commercial-scale solutions tomorrow — and secure America's position as the world leader in carbon removal innovation.

Carbon removal is projected to become a trillion-dollar industry by 2050, and the US is already home to more than 200 companies working to advance these solutions. Carbon removal credit markets, which can enable new revenue streams in the US and contribute to GDP growth, are a key part of this economic potential. Globally, governments and corporations are creating demand for carbon removal credits, driven by consumer preferences, national climate commitments, and the need for economic stability in a changing climate. This year alone, the voluntary carbon removal market has generated nearly $3 billion in sales, doubling since the end of 2024. Capturing this market will drive growth across American manufacturing, engineering, and infrastructure sectors, while opening up entirely new revenue streams through credit markets and exportable technologies.

Building this industry from the ground up also means creating a workforce for the future. Carbon removal offers durable, high-quality jobs across the country, including construction, operation, monitoring, and more. Strategic RD&D funding can support the carbon removal industry and its associated jobs in a just energy transition.

This memo outlines the key RD&D priorities within the Department of Energy's (DOE) carbon management portfolio and other relevant agencies, including direct air capture, marine carbon removal, biomass carbon removal and storage, and $CO_2$ transport and storage, for FY2026 funding. We offer these recommendations to help guide FY2026 investments that responsibly advance innovation, economic development, and US climate leadership.

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# Direct Air Capture

**State of the Field**

Direct air capture (DAC) technologies can be a strategic tool for bolstering US leadership in the crucial areas of climate, economy, and energy. These facilities offer a range of benefits, including the creation of thousands of well-paying jobs, promotion of economic growth in industrial and energy transition communities, and enhancement of domestic supply chains. In combination with private sector funding, the federal government's significant investment of more than $2 billion across the Regional DAC Hubs program, the DAC Pre-Commercial Technology Prize, and the CDR Purchase Pilot Prize supports more than 35 different pilots and demonstrations across at least 15 states — underscoring the strategic importance of DAC technologies in shaping the energy and economic future.

The DAC sector is not only a promising field but also a rapidly growing one, attracting startups, research institutions, and corporations. Currently, there are approximately 142 DAC companies, with at least 72 of them based in the US. Globally, 27 DAC plants are commissioned and in operation, capturing almost 10,000 tons of $CO_2$ annually. To date, DAC developers have secured over two and a half million tons in offtake agreements, representing over $1 billion in current demand — a signal that many projects are progressing and driving market expansion.

Today, the US is on track to host three commercial-scale plants. That includes Stratos, South Texas DAC Hub, and Project Cypress, located in Texas and Louisiana. Stratos, currently under construction in Ector County, Texas, has successfully secured a Class VI permit to store the captured carbon in underground geologic storage. It is expected to be operational by late 2025, with a nameplate capacity of 500,000 tons per year. The South Texas DAC Hub and Project Cypress are making significant strides through the design phase pending a Final Investment Decision (FID), with plans to break ground in 2025 and continue their build-out through 2029.

Continued investment in DAC supports a portfolio of benefits for the US:

- **Economic growth**. Large-scale deployment of DAC (i.e., at least 500,000 tons/year) can generate between 540 and 1,370 average annual jobs over the 5-year construction period, including project investment and supply chain jobs. An additional 300 to 420 ongoing jobs are associated with operating and maintaining the project, as well as related supplier activities, over the facility's lifetime. Furthermore, employment and growth in DAC infrastructure can also help revitalize industrial corridors by co-locating with legacy energy communities, transforming former fossil-dependent regions into clean energy hubs. DAC technologies impact a wide range of industries, including energy, steel, concrete, chemicals, mining, and water treatment; this creates new opportunities, efficiencies, and revenues in said sectors.

- **Driving innovation through R&D and US leadership**. DOE has coordinated research and development (R&D) efforts across the CDR value chain, including the foundational science underlying materials and chemicals. Liquid solvents and solid sorbents — the primary materials used in DAC today — have wide applications across power generation, manufacturing, oil and gas, and carbon management industries. DOE accelerates advancements in materials science, electrochemistry, and process engineering, solidifying American industries for global leadership.

- **Building infrastructure to maintain US competitiveness**. Early deployment fosters technical expertise, robust supply chains, and policy leadership, enabling a first-mover advantage before competitors can dominate. As an early entrant, the US is positioned to lead technology innovation, market creation, and governance for DAC. The EU, Canada, and Kenya are all ramping up investments in DAC. The EU has made advancements in its regulatory frameworks by introducing the first EU-wide voluntary framework for certifying carbon removals, carbon farming, and carbon storage in products across Europe, which arrives alongside an exploration of incorporating CDR in the EU's emissions trading system. Canada has established tax incentives, such as production tax credits and investment tax credits, for carbon removal at both the federal and provincial levels to encourage deployment. Over the last two years, Kenya has rapidly raised capital and deployed pilots, such as Project Hummingbird and Project Jacaranda, establishing itself as a hub for technology innovation with leaders like Octavia Carbon and Great Carbon Valley. These strides position Kenya as an emerging leader in the Global South and an attractive location to host pilots.

**Recent Milestones**

Over the past few years, Congress has made significant funding investments to help reduce the cost of DAC, thereby de-risking early-stage projects and attracting investments from corporations, airlines, and other major buyers. Public-private partnerships help share the risks and rewards of scaling carbon removal, accelerating deployment, and lowering costs. Below is a list of DOE programs that build momentum for US DAC businesses to enter and lead the global market:

- The Regional DAC Hubs program is a $3.5 billion program to finance the development of four megaton-capacity DAC hubs across the US. As the first large-scale US deployments of DAC, these hubs offer an opportunity to define the field with high-quality projects that create robust environmental, public health, and economic benefits.

- The CDR Purchase Pilot Prize offers $35 million in cash awards to teams with CDR proposals that will deliver carbon removal credits. This program aims to innovate offtake agreements with CDR project developers, supporting the development of a CDR

purchasing market and accelerating industry growth. The CDR Purchase Pilot Prize has selected 24 semifinalist winners across DAC, biomass, mineralization, and storage pathways, representing 11 states.

- The DAC Pre-Commercial Technology Prize awards up to $3.2 million in cash prizes and $800,000 in technical assistance vouchers to teams that identify a critical need in the DAC industry and develop a solution to address the gap. This program focuses on the steps of ideation and entrepreneurship needed to prepare technologies and businesses for commercialization. Seven semifinalist teams, representing five states, were selected for their winning concepts in the initial phase of the prize.
- The DAC Pilot Prize offers up to $52.5 million in cash awards to US-based, private technology developers that design, build, commission, and operate innovative and novel DAC pilot facilities capable of capturing at least 500 tonnes of $CO_2$ annually. The winners of the first phase of this program are anticipated to be announced later this summer.
- DOE is home to the first-ever dedicated Carbon Removal Research and Development (R&D) Program, established via the Energy Act of 2020. Federally supported R&D has a proven track record of dramatically decreasing the cost of emerging technologies, in addition to the expected decreases borne from private sector investments, learning by doing, and other supportive policies.
- The NETL DAC Center provides affordable material, module, and prototype-scale testing facilities. These facilities support public, private, and academic innovators to help maintain US leadership in DAC technology.
- The DOE's Office of Technology Transitions, in partnership with the Office of Fossil Energy, launched a lab call to accelerate CDR commercialization, focused on advancing measurement, reporting, and verification (MRV) best practices. The program supports the development of MRV tools and protocols to ensure transparent, rigorous, and bankable carbon removal claims across CDR approaches.

**FY26 Investment Priorities**

Investing in a diverse portfolio of DAC technologies can help hedge against the risk of any one approach failing to materialize and provide a diverse portfolio of accompanying benefits across industries, particularly in legacy energy regions. To maintain US leadership in CDR and accelerate the path for DAC from lab to commercial deployment, FY2026 federal investments should prioritize the following:

- **Continue investing in the Regional DAC Hubs program:** Sustain current momentum by maintaining DAC Hubs program funding and ensuring that awarded Phase 1 projects receive full support through subsequent phases.

- **Develop a Mid-Scale DAC Hubs Program**: Allocate remaining Infrastructure Investment and Jobs Act (IIJA) DAC Hubs program funds to establish a dedicated program for mid-scale DAC projects — those capturing 2,000 to 1000,000 tons of $CO_2$ per year — that are often too large for research grants or programs but too small to secure commercial financing, leaving them in the critical 'Valley of Death.' Focused investment at this scale would accelerate technology development, build deployment capacity, and ensure a stronger, more inclusive selection of DAC projects positioned for future scale-up.

- **Fund front–end engineering design (FEED) studies for $\geq$ 10,000 $tCO_2$/year facilities**: Support engineering design and project development for DAC systems targeting commercial-scale deployment. These funds should enable project developers to complete permitting, site-specific engineering, cost estimation, and pre-construction activities necessary to reach the Final Investment Decision (FID). Key performance metrics for projects would include the total cost per ton of $CO_2$ net removed, capital cost of the project, modeled energy use (< 2 $MWh/tCO_2$ preferred), land footprint, water consumption, storage pathway maturity and certainty, environmental health and safety impacts, and jobs created. Additionally, at the end of the project, developers should provide an integrated techno-economic model that demonstrates the cost and potential scalability limits of the approach.

- **Fund pilot-scale demonstrations at ~ 1,000 $tCO_2$/year**: Fund the build and operation of DAC pilot facilities that bridge TRL 5 - 7 technologies to TRL 8. These pilots should validate integrated system performance, energy use, and monitoring, reporting, and verification (MRV) under real-world conditions. For pilots to be considered, they should be targeting continuous operation for at least six months, integration of the complete DAC and storage system, and third-party MRV engagement. Key performance metrics would include the measured efficiency of the DAC process. including system uptime and operational reliability, measured sorbent performance over repeated cycling in real-world operating conditions, measured energy use under field conditions, land use footprint, water consumption under field conditions, and environmental health and safety metrics (e.g., air emissions, material degradation products). Additionally, at the end of the project, developers should be able to provide an integrated techno-economic model that demonstrates the cost and potential scalability limits of the approach.

- **Continue investment in research, development, and deployment (RD&D)**: Invest in RD&D to unlock breakthroughs in capture materials, process design, and systems integration that lower cost and accelerate commercialization.

- **Continue funding for the DAC Test Center at the National Energy Technology Laboratory (NETL).**
- **Continue investing in MRV:** Rigorous MRV can ensure that carbon removal credits are of high quality, giving purchasers confidence that they are getting what they pay for. For DAC in particular, robust MRV can ensure the acceptance of US DAC-generated credits globally and provide a competitive advantage for the American industry. A coordinated government approach to MRV R&D, alongside engagement with industry stakeholders to identify best practices and gaps, will significantly enhance confidence in credits created by DAC and other forms of CDR.
- **Continue R&D for capture materials, including solvents and sorbents.** Liquid solvents and solid sorbents are the dominant capture materials used for DAC today, with wide applications across various energy sectors. Continued R&D across these materials will be crucial in maintaining US leadership in materials science.
    - DOE should invest in R&D for the discovery of new materials and the enhancement of the safety and efficiency of current materials.
    - DOE should publish available research on the public and environmental health impacts of liquid solvents and solid sorbents, including their decomposition, water consumption, production, and byproducts. For example, amines — a common sorbent material used in DAC — have the potential to react with nitrogen compounds and form nitrosamines, a class of potentially carcinogenic compounds that may pose local exposure risks. These research efforts should directly inform public and environmental health impacts, siting and permitting decisions, and material selection choices to ensure responsible deployment and minimize environmental and health impacts.
    - The DOE should fund comparative life cycle assessments (LCAs) and toxicity assessments across a range of solid sorbents and liquid solvents, including considerations of recyclability and end-of-life impacts. This research will help identify materials with the lowest overall environmental and human health risks, informing responsible material selection, supply chain development, and waste management practices.

# Marine Carbon Removal

**State of the Field**

The ocean covers 70% of Earth's surface and is the planet's largest carbon sink. Through natural processes, the ocean already absorbs approximately one-third of carbon dioxide emissions and has the potential to store 17 times more carbon than soils and land biota combined. Ocean-based or marine carbon dioxide removal (mCDR) refers to technologies and approaches that leverage natural carbon absorption processes to maximize the amount of atmospheric carbon dioxide the ocean can remove. mCDR approaches are divided into two broad categories. Biological approaches aim to boost marine carbon dioxide removal by increasing $CO_2$ uptake in marine plants and microalgae and increasing carbon storage in the deep ocean (e.g., seaweed cultivation and sinking). Chemical and electrochemical approaches leverage ocean chemistry to increase the amount of $CO_2$ absorbed by and stored within seawater (e.g., ocean alkalinity enhancement). Both types of approaches hold promise for safe, scalable, and effective atmospheric carbon dioxide removal.

This potential has led to growing interest in mCDR across academia, industry, and philanthropy. Ongoing research is advancing the scientific understanding of this field; however, mCDR encompasses a wide range of approaches, each with varying levels of scientific and technical maturity, knowledge gaps, environmental and societal concerns, and regulatory requirements that must be addressed before deployment. Therefore, before any mCDR technique can be deployed at scale, further R&D is needed to ensure it is safe, scalable, affordable, and effective.

mCDR is a promising and emerging space in the global CDR market, projected to be a nearly $2.4 billion industry in its own right by 2032. The US has established itself as a global leader in the mCDR industry, with seven out of the ten largest mCDR companies based in the US. This industry leadership is largely thanks to federal investments — which have in turn catalyzed significant momentum in the private sector — that help advance innovations in mCDR approaches while creating high-quality jobs, expanding resiliency, and unlocking new economic benefits for Americans in coastal regions. However, as an industry, mCDR is in its infancy, and many outstanding R&D questions remain. Further work is needed to understand and verify the scalability and durability of marine CDR as an industry, along with its associated economic, environmental, and societal impacts.

To address these outstanding questions and maintain its position as the global leader in mCDR, the US requires a robust, integrated, and interdisciplinary research and development portfolio for mCDR. Increased federal funding is therefore necessary to support R&D for mCDR technologies, requisite tools to address remaining questions, and governance frameworks for the responsible development and deployment of mCDR.

**Recent Milestones**

Significant federal investments have been made in recent years to advance mCDR research in the US and to solidify its place as a world leader in this emerging market. Early federal investment in emerging technology spaces, like mCDR, provides a robust R&D foundation for future breakthroughs, which is essential to catalyzing the industry. This investment ensures that rigorous scientific and environmental standards are met, while also attracting and de-risking private sector investment. Recent, federally funded mCDR milestones include:

- **LOC-NESS:** A research project at the Woods Hole Oceanographic Institution (WHOI) to study ocean alkalinity enhancement in the Northeast US has been granted its EPA Marine Protection, Research, and Sanctuaries Act (MPRSA) permit, allowing it to begin operation of its first field trial. This project is a public-private partnership funded by the Carbon to Sea Initiative, NOAA's National Oceanographic Partnership Program (NOPP), and other allocations from NOAA and DOE.

- **NOAA/DOE mCDR memorandum of agreement (MOA)**: Established for DOE's Office of Fossil Energy (FE) and NOAA's Ocean Acidification Program (OAP) to collaboratively advance mCDR R&D over a five-year period through at least 2029. This MOA leverages the capacities and strengths of each agency to meet the challenges of the field.The MOA authorizes agencies to investigate opportunities for mCDR testbeds, a need widely identified in the mCDR community.

- **Pacific Northwest National Laboratory (PNNL) & Ebb Carbon Pilot:** A public-private partnership enabled the first-of-its-kind deployment of an electrochemical mCDR pilot system, capable of removing 100 tons of $CO_2$ per year. Hosted at the PNNL in Sequim, Washington, the project's funds were received from Ebb Carbon, NOAA's Pacific Marine Environmental Lab (PMEL), DOE's Water Power Technologies Office (WPTO), and the University of Washington.

- **DOE, Advanced Research Projects Agency (ARPA-E) SEA-$CO_2$:** $36 million for 11 projects across eight states to accelerate the development of mCDR capture and storage technologies, funded through DOE's Sensing Exports of Anthropogenic Carbon through Ocean Observation (SEA-CO2) program at ARPA-E.

- **National Oceanographic Partnership Program(NOPP) mCDR:** $24.3 million for 17 academic projects that advance marine carbon dioxide removal research. Funded through NOPP, NOAA's Ocean Acidification Program (OAP), NOAA's Global Ocean Monitoring and Observing Program, DOE's FE and WPTO offices, the Office of Naval Research (ONR), the National Science Foundation (NSF), and ClimateWorks Foundation.

**FY26 Investment Priorities**

To maintain US leadership in marine carbon removal, FY2026 federal investments should prioritize the following:

- **Continue Congressional support for the NOAA/DOE MOA.**
    - Continue investment for mCDR test beds and pilot projects. mCDR test beds are a need widely identified within the mCDR community. As seen in the marine energy field, test sites serve as a mechanism for expediting research, reducing costs, and minimizing potential environmental impacts. Support the release of existing funds that have already been allocated for this purpose.
    - Continue investment in testing mCDR approaches at mesocosm and lab scale.
- **Continue support for the federal mCDR Interagency Working Group.**
    - Develop a federal code of conduct for responsible mCDR RD&D.
    - Steward the development of standards for assessing impacts on ecosystems and coastal economies.
- **Engage in international cooperation and coordination on measurement, monitoring, reporting, and verification (MMRV)** and best practices for accounting for mCDR in nationally determined contributions.

# Biomass Carbon Removal and Storage

**State of the Field**

The US has a strategic advantage as a grower and exporter of biomass, the raw material of biofuels, bioenergy, and bioproducts. However, more than half of the existing resources in our forests, farms, and cities are not well-captured by existing markets. The introduction of biomass carbon removal and storage (BiCRS) fills a key niche in the bioeconomy by valorizing hard-to-dispose-of waste as price-advantaged feedstocks.

To unlock these opportunities, we must advance conversion technologies (including their miniaturization and modularization), develop regionally tailored systems for feedstock collection and conversion, and enable municipalities and regional partnerships to implement them. These new technologies can create jobs and industry in urban centers *and* our most remote and rural communities, reduce costs for wildfire and waste management, and generate breakthroughs in synthetic biology and advanced manufacturing.

The biomass industry in the US has experienced significant growth over the past quarter century, as new technologies have enabled the utilization of 340 million short dry tons of corn, wood, and other waste for fuel, heat, and power. The industry reflects $53 billion in corn ethanol, enabled by the California Low Carbon Fuel Standard (LCFS) and the federal Renewable Fuel Standard (RFS). Biodiesel production in the US is a $15 billion industry, uniquely spurred by the RFS and the LCFS. Today, there is new interest in biomass for ethanol, biodiesel, methanol, or hydrogen, driven by the adoption of aggressive climate action plans from the International Maritime Organization and the International Civil Aviation Organization.

The wood pellet industry has grown steeply from nonexistent in 2000 to a $1.86B industry today. The majority of wood pellets are exported to Europe, where biomass heating and power plants provide 59% of renewable energy consumption. Industrial bioenergy has also fueled related, globalized industries, such as biochar (as an agricultural and cement additive) or syngas (as a source of hydrogen and feedstocks for e-fuels and synthetic chemicals).

Many BiCRS technologies are relatively new to this space and can fill a unique role in building out biomass sourcing and incentives. Biochar, which can be produced from wood or corn stover and is not suitable for conventional biofuel production, is already a $0.7B global industry currently dominated by Asian producers. Biomass burial is highly scalable and utilizes woody feedstocks. While the current market consists of only a handful of US companies, they have found eager partners among forest managers in wildfire zones. Only a few companies dominate bioliquid injection, but it provides niche solutions for wet waste and bio-oils. Bioenergy with carbon capture and storage (BECCS) is the largest extant industry, which may result in net removals of atmospheric carbon dioxide. This field has delivered 10,000 tons of carbon removal,

but has been contracted to remove over two thousand times as much, representing the enormous scale-up potential anticipated for this pathway.

The future of this industry is heavily dependent on policy and supply chain management. In Europe and the UK, renewable energy standards have driven industry growth, as 45Q tax incentives are expected to do in the US. A retraction of these incentives in response to sustainability and social concerns, as the UK government announced this year, would likely lead to a contraction in the industry. Even at current support levels, demand for biomass is increasing due to scaling demand for green jet fuel; hydrogen; and other fuels, chemicals, and products. There is a need to secure biomass supplies that can be realized without threatening sustainability.

**Recent Milestones**

- In 2022, the Biomass Feedstock National User Facility (BFNUF) began offering technical expertise, research facilities, and laboratory services that have helped de-risk biofuel production using corn and pine residues.
- In 2023, the DOE's Bioenergy Technology Office (BETO) finalized updates to its flagship Billion-Ton Report. Billion-Ton 2023 is the fourth in a series of assessments that have guided industry and investors on biomass resources in the United States.
- In 2023, DOE's BETO invited 69 field experts to review 303 projects and $561 million invested over the previous two years by that office. The next project review is anticipated in 2025. These projects included:
    - The Ecosystem Services Entrepreneurship Technical Assistance program, developed through Argonne National Laboratory, has created a farmer-led coalition and a farmer-reviewed decision tool to support the adoption of perennial crops for biomass production. The program was highly rated for its approach, process, outcomes, and impact. Critical next steps included the development of a robust market for biomass purchasing and integration into nutrient trading and ecosystem service payment schemes.
    - The National Availability and Costs of Cover Crops Managed as Biofuel Feedstocks program through Oak Ridge National Laboratory provided estimates of the potential yield and revenue from cover-cropping systems with oilseed crops to estimate probable adoption and national scale relevance to feedstock resources. Critical next steps, which DOE is already engaged in, include identifying optimal regional cropping systems. Additional funding would provide technical assistance for farmers and communities in identified regions, allowing them to scale up adoption and establish a demonstration-scale plant to ensure an offtake market.

- In 2024, the National Renewable Energy Laboratory and Lawrence Livermore National Laboratory initiated critical MRV research as part of DOE's Office of Technology Transitions and the Office of Fossil Energy's lab call for the commercialization of CDR technologies.
- In 2024, DOE's FE funded seven biomass carbon removal and storage companies under the Carbon Dioxide Removal (CDR) Purchase Pilot Prize. Each of these companies utilized waste biomass for the durable removal and storage of atmospheric carbon.
    - Projects from Pine Bluff, AR to El Segundo, CA, proposed the utilization of woody waste, which would leverage forest management waste to deliver pilot-scale carbon removal.
    - Mobile platforms for biochar application (Houston, TX) and modular systems for disposal (Silver Spring, MD) received support for small-scale pilot projects.
    - Proposed work in Texas, Colorado, and California involves injecting bio-based liquids underground for carbon removal, utilizing conversion and well infrastructure, as well as waste from manure and agricultural sources.

**FY26 Investment Priorities**

FY2026 federal investments can maintain US leadership as a supplier of sustainable biomass feedstocks while synergistically realizing the potential of a biomass carbon removal and storage industry.

- **Enable the utilization of woody biomass to address wildfire challenges.**
    - *The United States Department of Energy shall:*
        - Establish commodity grades and carbon intensity scores for woody feedstocks that apply to multiple end-users and are adaptable to small and shifting supplies.
        - Support affordable biomass characterization services of woody biomass and biochar to enable project scale-up.
- **Support rural and remote communities in utilizing value-added agricultural and forest thinning waste, including biochar and biomass burial.**
    - *The United States Department of Energy shall:*
        - Fund pilot-scale projects for small, modular conversion reactors that are transportable by truck or tractor and capable of meeting material processing and air quality thresholds required of full-size plants.

        - Fund pilot-scale projects for biomass burial, prioritizing small and transient biomass resources.
        - Leverage modular and mobile conversion reactors for technical assistance to municipalities, with the intent of supporting small business innovation research grants to optimize technologies in high-impact regions.
        - Lead a Small Business Programs funding call to build a small industry of regional operators with mobile, modular systems capable of addressing remote and rural biomass needs.
        - Invest in life-cycle and technoeconomic analyses for new biomass carbon removal technologies, including investigation of monitoring, reporting, and verification strategies for biomass burial and biochar applications.
    - *The United States Department of Agriculture (USDA) shall:*
        - Invest in a research network across ARS sites to identify the impacts of biochar across different soil types and application rates to understand the benefit to agriculture, forestry and the environment, as proposed in the Biochar Research Network Act.
        - Bolster investments in programs that support producer-led research (e.g. the Sustainable Agriculture Research and Education program) and co-development of research with producers (e.g. Cooperative Extension, Conservation Innovation Grants) to advance in situ production of biochar and improve testing of biochar use in different agriculture and forestry systems.
- **Facilitate a next-generation of energy crops, prioritizing low carbon intensity.**
    - *The United States Department of Energy shall:*
        - Establish commodity grades and carbon intensity scores for oilseed feedstocks applicable to multiple farming regions and end users.
        - Fund demonstration-scale conversion reactors capable of processing oilseed and lignocellulosic feedstocks.
    - *The United States Department of Agriculture (USDA) shall:*
        - Improve life cycle assessments to determine carbon intensity scores of existing and alternative feedstocks (e.g. waste, winter annual oilseeds) to identify alternative feedstocks that avoid land-use change and additional competition with food and fiber production

        - Establish a national soil carbon monitoring network that can estimate the regional carbon sequestration potential of existing conservation practices, including biochar and cover crops, and integrate this data into models for biomass sourcing of carbon negative feedstocks (e.g., GREET)

- **Unlock the potential of underutilized biomass resources from agricultural and urban sources of wet and municipal solid waste.**
    - *The United States Department of Energy shall:*
        - Fund regional landscape design studies that are paired with technical assistance and small business grants, to identify opportunities for operational supply chains. These interventions will also mitigate risk and costs associated with bioenergy production while delivering economic competitiveness, energy independence, and social benefits.
        - Invest in pilot-scale studies of biological-based conversion processes that utilize synthetic biology tools with genetically tractable, industrially robust organisms.
        - Invest in life-cycle and technoeconomic analyses for new biomass carbon removal technologies, including investigation of monitoring, reporting, and verification strategies for biomass liquid injection and anaerobic digestion.
    - *The United States Department of Agriculture shall:*
        - Expand research to identify regionally tailored guidance for the use of compost or organic amendments as fertilizer in agricultural systems, and for soil additives, including biochar, that protect soil and farmer health.
    - *The United States Environmental Protection Agency*
        - Revise effluent emissions guidelines for concentrated animal feeding operations, ensuring protection of domestic clean water resources and air quality.
- **Cross-functional opportunities for sustainable biomass production and enabling a domestic bioeconomy.**
    - *The United States Department of Energy shall:*
        - Advance the technical foundations for measuring, monitoring and reporting greenhouse gas removal through biomass management, with

support from the National Renewable Energy Laboratory and Lawrence Livermore National Laboratory.

        - Prioritize continued support for the Biomass Feedstock National User Facility, with a focus on materials and conversion technology testing, with support from the Idaho National Laboratory.

    - *Interagency funding shared between the United States Department of Energy and the United States Department of Agriculture shall:*

        - Update the Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model to provide carbon intensity scores that reflect the new feedstocks and any direct or indirect land-use change associated with their production.

# Carbon Storage and Transportation

**State of the Field**

The build-out of safe and reliable $CO_2$ transportation and storage infrastructure will be critical for scaling up carbon management. Significant progress has been made in recent years through investments in federal RD&D, as well as the development and implementation of tax incentives and regulatory frameworks for safe and reliable projects. However, continued commitment to existing DOE programs and additional support are needed to ensure that these investments will lead to a thriving, robust, and innovative carbon management industry in the US over the next decade.

There is broad global support for carbon management technologies, as well as recognition that transportation and geologic storage infrastructure will need to be developed in the coming decades to support this growing industry and achieve net-zero goals. Government support is reflected in various carbon management initiatives that bring together dozens of countries, including major and emerging economies.

As of July 2024, 50 carbon capture and storage projects were operating worldwide, 44 were under construction, and over 600 were in development. Countries with the most operational projects include the US, UK, Canada, Norway, and China. Significant interest and investment in carbon management exist in the EU, Saudi Arabia, the Middle East, and Southeast Asia. There is also growing interest in South America, with Brazil leading, and Africa, in countries like Nigeria, South Africa and Kenya.

Recently, there has been a significant global uptick in transportation and storage efforts, focused on "hubs and clusters" where shared infrastructure can provide economies of scale for various $CO_2$ capture projects. The Porthos project in the Netherlands is an example of this concept, where $CO_2$ from industry in the port of Rotterdam will be transported and stored in deep geologic reservoirs under the North Sea. Construction is underway for that project, and over 200 transport and storage projects are in various stages of development around the world.

There are 5,500 miles of existing $CO_2$ pipeline in the US, but DOE estimates that we need between 10,000 and 15,000 miles by 2030 and 30,000 and 96,000 miles by 2050. This reflects pipeline needs for carbon capture from industrial sources and direct air capture. The Department of Transportation has regulated the safety of $CO_2$ pipelines since 1979. The Pipeline and Hazardous Materials Safety Administration (PHMSA) has been overseeing these regulations since its establishment in 2004. In January 2025, PHMSA released proposed rules to enhance the safety of $CO_2$ pipelines, but these proposed requirements have not been published in the Federal Register.

The total amount of $CO_2$ geologically stored between 2016 and 2023, as reported to EPA, was approximately 63 million metric tons. Most of that $CO_2$ was injected and stored as part of enhanced oil and gas recovery or disposal wells, with monitoring and verification approved by the EPA and consistent with international reporting guidelines. Approximately 3.7 million tons of $CO_2$ were injected and stored in dedicated geologic storage reservoirs under EPA's Underground Injection Control Class VI permitting program.

DOE has funded RD&D of $CO_2$ storage in geologic reservoirs since the 1990s, including capacity assessments, pilot tests, and the first commercial-scale projects. More work is underway at DOE to develop $CO_2$ storage resources, and EPA is also an essential federal partner. As of early May 2025, EPA was reviewing 170 Class VI injection well permits for 58 $CO_2$ storage projects. States with primacy for Class VI permitting also have additional permits under review.

**Recent Milestones**

The most significant recent milestones for transport and storage are the 2022 revisions to the 45Q tax credit in the Inflation Reduction Act, which increased the value of the credit and generated investment, and the $12 billion in federal funding provided to DOE through the Infrastructure Investment and Jobs Act (IIJA). Specific elements of IIJA that relate to transport and storage include:

- Carbon Dioxide Transportation Infrastructure Finance and Innovation (CIFIA) Program – $2.1 billion in grants and loan support for the development of $CO_2$ transportation infrastructure needed to link clusters of $CO_2$ capture projects with $CO_2$ storage hubs.
- Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Program – $2.5 billion in funding from IIJA for the development of $CO_2$ storage hubs. Forty-eight projects have been selected for this program.

**FY26 Investment Priorities**

Developing robust and flexible carbon storage infrastructure can help ensure safe and permanent storage at the scale required to meet climate targets, while creating new economic opportunities across regions with geologic storage resources. The US is uniquely positioned to be a global leader in $CO_2$ transport and storage, with abundant subsurface capacity, deep geologic expertise, and existing infrastructure. To capitalize on this advantage and accelerate US leadership in carbon management infrastructure, FY2026 federal investments should prioritize the following.

Carbon Storage and Transport at DOE

DOE should continue to support infrastructure development for $CO_2$ transport and storage RD&D to enhance performance and reduce the costs of site characterization, active and post-injection operations, and transport.

- **Continue funding for the Carbon Storage Assurance Facility Enterprise (CarbonSAFE) program.** CarbonSAFE is accelerating the development of commercial-scale geologic carbon storage projects and associated $CO_2$ transport infrastructure by focusing on the detailed site characterization, permitting, and construction stages of project development.
    - Conduct research to improve subsurface characterization for mineralization pathways, including identifying and mapping reactive formations, understanding geochemical kinetics (via use of test wells), and assessing long-term storage capabilities. Priorities include generating robust data on mineralization rates and performance, developing technologies to accelerate in-situ reactions, and improving models to predict long-term storage performance. Investments should also support the development of fit-for-purpose monitoring approaches aligned with Class VI requirements and continue field-scale demonstrations to de-risk mineralization as a viable, scalable storage pathway.
- **Continue funding for the Carbon Basin Assessment and Storage Evaluation (CarbonBASE) program.** CarbonBASE focuses on addressing issues that may arise as large amounts of $CO_2$ are stored at various locations within specific geological basins, which often span entire regions, cross state boundaries, and include state, federal, and Tribal lands. The program aims to collect geological data from US basins and develop a comprehensive set of tools for rapid and effective site screening, site characterization, development, and basin-scale resource monitoring and management. The data and tools developed under CarbonBASE will be designed to assist project developers in carefully selecting storage sites, facilitate and expedite the permit approval process for regulators, and provide a system for monitoring and managing storage resources within basins and sub-basins.
- **Continue funding for the Carbon Storage Technology and Operations Research Facility (CarbonSTORE) program.** CarbonSTORE is a multi-year RD&D initiative that will establish a series of field laboratories in various geological settings to enhance data collection for new technology development, accelerate the validation of emerging technologies, and provide real-world performance feedback for operational improvements and optimization. Novel, potentially lower-cost technologies — such as tools for real-time monitoring of pressure evolution; pressure interference; and their effects on injectivity, storage efficiency, and induced seismicity risk — can be compared side by side with existing technologies for achieving these purposes.

- **Enhance transparency and knowledge transfer of spatial data on carbon transport and storage by fostering more integrated national-level data on transport and geological storage opportunities.**
    - Create an open-source spatial dataset that uses AI to consolidate publicly available yet disparate project data, providing real-time information to project developers, states, researchers, and the public on project and well data and geological information. The DOE currently holds a significant amount of data and information on NETL's Energy Data eXchange (EDX), but the primary target audience is researchers, which makes it difficult for others to find and extract the data. The CCUS Map could serve as a good model.

Carbon Transport and Storage at EPA

- **Continue providing funding for EPA and state underground injection control (UIC) programs to implement the Class VI program,** including resources for primacy, regulatory development, permitting, and public outreach and communication.
- **Ensure that provisions of the Greenhouse Gas Reporting Program (GHGRP) that relate to carbon capture, utilization, and storage are retained** and that EPA has the budget to execute those provisions to support 45Q (subparts PP, UU, RR, VV).
- **Provide funding to initiate regulatory updates and technical guidance that clarifies how in-situ mineralization can be permitted under the Class VI framework**, informed by emerging field data and DOE-supported RD&D. This would establish a clear regulatory pathway for mineralization storage, enabling responsible scaling and fostering market confidence.

Carbon Transport at PHMSA

To provide public safety and assurance in carbon transportation via pipeline:

- **Reauthorize PHMSA and finalize the $CO_2$ safety rulemaking announced in January 2025** to provide public safety and assurance in carbon transportation via pipeline. Critical elements of the rulemaking include:
    - Establishing new safety measures for all $CO_2$ pipelines.
    - Establishing design, installation, operation, maintenance, and reporting requirements for $CO_2$ gas pipelines (currently not covered).
    - Establishing new requirements that pipeline operators must adhere to when converting existing pipelines to transport $CO_2$ in different phases.

- Establishing an emergency planning zone for improved emergency response and public communications.
- Implementing more robust requirements for communicating with the public during an emergency.
- Requiring first responder training, $CO_2$ detection devices, and other relevant equipment is available for local first responders.

# Carbon Utilization

### State of the Field

Carbon utilization is a crucial means for certain carbon removal solutions to establish early markets and scale their businesses in the future. DOE has the potential to fund breakthroughs in carbon utilization that can support the development of DAC and BECCS technologies. However, many carbon utilization processes have received insufficient innovation funding to date, as they must compete with carbon emissions-intensive alternatives and cannot yet compete solely on price. With sufficient innovation funding, these solutions can reduce costs and achieve greater adoption.

### FY26 Investment Priorities

In particular, DOE should:

- **Fund small pilots focused on reactive capture and conversion into low-carbon fuels and chemicals**, up to $10M per project for up to five projects.
- **Fund small pilots of $CO_2$ utilization for building materials**, with $10M per project for up to five projects.
- **DOE should fund LCA support for utilization pathways**, enabling these solutions to appropriately and robustly monetize their carbon emissions reductions.

# General Carbon Removal

**State of the Field**

Carbon removal is at an inflection point in the US today. Startups are quickly moving into the pilot and demonstration phase, where we will gain a better understanding of the techno-economic performance of a range of solutions in real-world conditions. Doing so will require significant private sector support, both in the form of voluntary carbon credit purchases and finance for first-of-a-kind facilities. Financing projects is especially challenging given the scale of projects ($10Ms–$100Ms per facility) with significant technical risk and a lack of experience from investors in financing these projects.

Furthermore, a new generation of carbon removal approaches is just emerging from the lab and offers the potential to leapfrog over first-generation solutions in cost and performance. However, these newer technologies will face challenges in raising the necessary capital to compete with incumbents in the challenging macroeconomic environment.

**Recent Milestones**

- **DOE is home to the first-ever dedicated Carbon Removal Research and Development (R&D) Program, established via the Energy Act of 2020.** Federally supported R&D has a proven track record of dramatically decreasing the cost of emerging technologies, in addition to expected cost decreases from private sector investments, learning by doing, and other supportive policies.
- **The CDR Purchase Pilot Prize offers $35 million in cash awards to teams that provide CDR proposals that will deliver carbon removal credits.** This program aims to innovate offtake agreements with CDR project developers, supporting the development of a CDR purchasing market and accelerating industry growth. The CDR Purchase Pilot Prize has selected 24 semifinalist winners across DAC, biomass, mineralization, and storage pathways, representing 11 states.

**FY26 Investment Priorities**

To maintain US leadership in carbon removal, DOE should prioritize the following:

- Fund small pilots at $50M-scale, at $5M-10M/project, for kiloton/year-scale projects across a range of pathways. The DOE should focus on technologies that offer breakthroughs in cost and scale potential, as well as those that provide the greatest strategic advantage for the US as a developer of carbon removal solutions.

- Fund $50M-scale pre-FEED and FEED studies for projects over 10kiloton/year-scale at $5-10M/project
- Support $50M in CDR purchasing from high-potential US CDR projects, designed in a way to crowd in as much private voluntary carbon removal purchasing as possible.
- Fund $10M in support of developing best practices for lifecycle carbon accounting for the full range of carbon removal solutions.
- Fund $5M in analysis related to integrating carbon removal into existing industrial processes; analysis should include the potential for cost reductions for integrated systems as well as co-benefits to communities and workforce implications.
- Fund $2M for analysis on AI's potential to accelerate technology innovation for carbon removal.
- Fund $10M in the identification of site locations for CDR hubs capable of supporting 100M/year-scale carbon removal deployments, and what types of regulatory pre-permitting can facilitate development in these areas.
- Continue investment in RD&D for the full portfolio of carbon removal solutions. RD&D investments can unlock breakthroughs in capture materials, process design, and systems integration that lower cost and accelerate commercialization. Specifically, funding for carbon removal RD&D should be allocated for DOE's Office of Fossil Energy (FE), the Office of Science, the Office of Energy Efficiency and Renewable Energy (EERE), and the Advanced Research Projects Agency - Energy (ARPA-E).
- Continue investing in MRV. Rigorous MRV can ensure that carbon removal credits are of high quality, giving purchasers confidence that they are getting what they pay for.

# Appendix A: Fiscal Year 2022-2024 Budget Tables

**Table 1: Carbon Removal Funding by Department**

| Carbon Removal Funding by Department* | | | |
|---|---|---|---|
| Department | FY22 Enacted | FY23 Enacted | FY24 Enacted |
| Department of Energy | $994,000,000 | $840,000,000 | $818,000,000 |
| Department of Defense | $10,000,000 | $10,000,000 | $10,000,000 |
| Department of Commerce | $3,000,000 | – | – |
| Department of the Interior | $2,338,500 | $2,138,500 | $1,488,500 |

**Table 2: Carbon Removal Funding at the Department of Energy**

| Carbon Removal Funding at the Department of Energy* | | | |
|---|---|---|---|
| Office | FY22 Enacted | FY23 Enacted | FY24 Enacted |
| Fossil Energy | $939,000,000 | $770,000,000 | $770,000,000 |
| Science | $35,000,000 | $50,000,000 | $25,000,000 |
| Energy Efficiency and Renewable Energy | $20,000,000 | $20,000,000 | $23,000,000 |

**Table 3: Carbon Removal Funding at the Department of Defense**

| Carbon Removal Funding at the Department of Defense* | | | |
|---|---|---|---|
| Office | FY22 Enacted | FY23 Enacted | FY24 Enacted |
| Force Protection Applied Research | $10,000,000 | $10,000,000 | $10,000,000 |

**Table 4: Carbon Removal Funding at the Department of the Interior**

| Carbon Removal Funding at the Department of the Interior* | | | |
|---|---|---|---|
| Office | FY22 Enacted | FY23 Enacted | FY24 Enacted |
| United States Geological Survey | $2,338,500 | $2,138,500 | $1,488,500 |

*Funding totals for carbon removal in Tables 1–4 reflect allocations for specific pathways: direct air capture, biomass carbon removal and storage, marine carbon removal, and carbon mineralization. $CO_2$ removed through technologies like direct air capture requires a storage location, which makes dedicated geologic storage an essential complement to this carbon removal pathway. However, because geologic storage infrastructure is frequently paired with point-source carbon capture and storage projects, which do not constitute carbon removal, we excluded it from the total funding levels for carbon removal in this table.

**Table 5: Federal Funding for Carbon Removal and Storage by Pathway**

| Federal Funding for Carbon Removal and Storage by Pathway | | | |
|---|---|---|---|
| Pathway | FY22 Enacted | FY23 Enacted | FY24 Enacted |
| Direct Air Capture | $923,000,000 | $715,000,000 | $705,000,000 |
| Marine Carbon Removal | $10,000,000 | $20,000,000 | $15,250,000 |
| Biomass Carbon Removal and Storage | $500,000 | - | - |
| Geologic Storage | $602,988,500 | $619,688,500 | $606,200,000 |
| Carbon Utilization | $70,000,000 | $115,250,000 | $119,062,500 |