ENGINEERED CARBON REMOVAL: MARKETS AND FINANCE POLICY RECOMMENDATIONS

C2ES CENTER FOR CLIMATE AND ENERGY SOLUTIONS

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Meeting our long-term climate goals will require the large-scale deployment of a multitude of new, innovative technologies and low- and zero-carbon fuels across every sector of the economy. First-of-a-kind technologies will need to rapidly reach commercial scale without sacrificing safety, social equity, or sustainability. This can only be achieved through system-wide collaboration between corporate incumbents, financiers, innovators, communities, and policymakers. To help meet this challenge, C2ES has created four distinct technology working groups focused on the technologies of engineered carbon removal, sustainable aviation fuel, long duration energy storage, and clean hydrogen. This brief presents findings and recommendations from the engineered carbon removal working group.

OVERVIEW

There is broad consensus that both aggressive greenhouse gas emissions reductions and gigatons of carbon dioxide removal (CDR) will be needed to limit the rise in average global temperatures to below 2 degrees C above preindustrial levels. In addition to widespread deployment of nature-based CDR solutions like reforestation and agricultural soil management, new forms of engineered carbon removal (ECR) will also be necessary. ECR offers several advantages, such as larger removal and scalability potential, greater durability, and more locational flexibility. In recent years, there has been rapid growth in public and private investment in ECR technologies, including direct air capture (DAC), biomass with carbon removal and storage (BiCRS), enhanced rock weathering, and marine carbon dioxide removal, that has helped make many of these technologies commercially viable. However, the entire ECR industry will need to be rapidly scaled to achieve the gigaton levels of removal necessary to meet 2050 climate goals. To help meet this challenge, the Center for Climate and Energy Solutions (C2ES) has established a technology working group that convenes stakeholders from across the ECR ecosystem to examine the key technical, market, and policy solutions needed to achieve rapid and responsible deployment and commercialization of ECR. This brief offers five policy recommendations focused on addressing the financial and market barriers to scaling this critical-path technology.

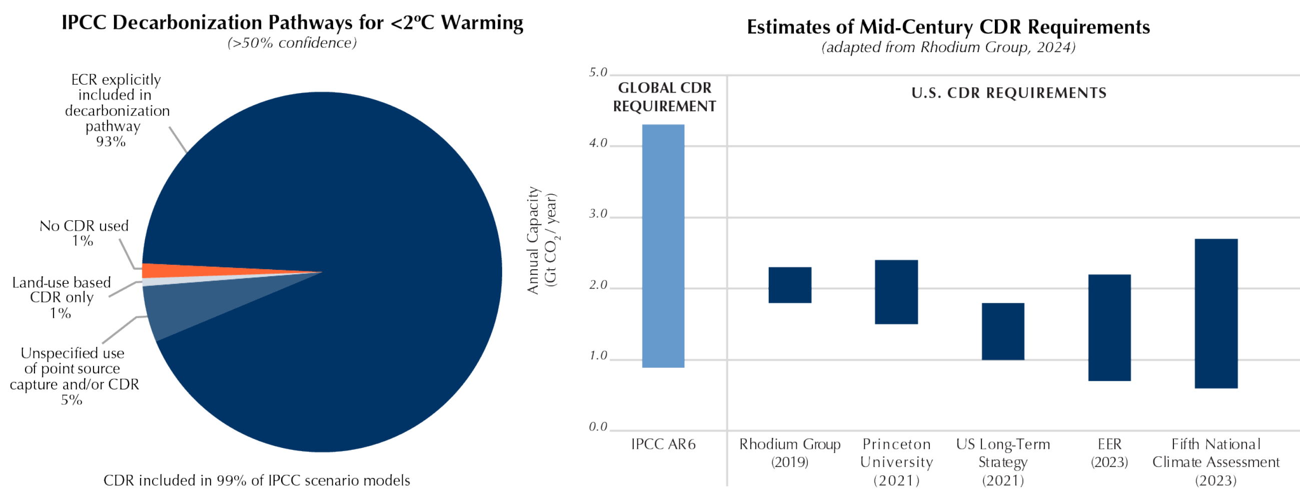
INTRODUCTION

THE GROWING IMPORTANCE OF CARBON REMOVAL

The Intergovernmental Panel on Climate Change (IPCC) has stated clearly that ECR will be a necessary component of global decarbonization, with nearly every IPCC modeled scenario that would meet the goals of the Paris Agreement including some form of ECR (**Figure 1**). The necessary scale of such carbon removals is significant, with the average IPCC decarbonization pathway requiring over three gigatons of CDR annually by 2050 through engineered techniques such as DAC, BiCRS, or enhanced rock weathering.[1] In the United States alone, reaching net-zero greenhouse gas emissions by 2050 will require 0.6–2.7 gigatons of CDR annually, according to an aggregate study of decarbonization scenarios by Rhodium group.[2] For comparison, in 2022, only 130 thousand metric tons of carbon dioxide was removed from the atmosphere using engineered techniques—about four orders of magnitude lower than what will be necessary by mid-century.[3]

A great deal of growth in technological innovation, policy development, and investment in carbon removal technologies has occurred over the past decade. In 2022, there was $1.5 billion of public and private investment in 131 CDR companies, compared to only $4 million of investments across three companies in 2013.[4] However, to achieve the 10,000-fold increase in annual ECR that will be needed in the next 25–30 years, this momentum must grow. An entire new ecosystem for carbon removal technologies, developers, long-term customers, and supporting infrastructure will be necessary. Thoughtful and durable federal policy will be critical to ensuring that this ecosystem can grow, and that novel ECR technologies can be widely deployed, i.e., successfully bridging the “innovation valley of death” to achieve first-of-a-kind—and ultimately “nth-of-a-kind”—commercial scale.

FIGURE 1: Carbon Dioxide Removal in Global and U.S. Decarbonization Pathways



Of 695 modeled decarbonization pathways in the IPCC Assessment Report Six (AR6) that have a greater than 50 percent probability of keeping global warming below 2 degrees C, only nine require no form of carbon removal and instead invoke significant demand-side interventions, such as reduced energy demand or dietary changes. Every pathway that keeps warming below 1.5 degrees C requires CDR.

Sources: Edward Byers et al., “AR6 Scenario Explorer and Database,” International Institute for Applied Systems Analysis (IIASA), accessed June 7, 2024, https://data.ece.iiasa.ac.at/ar6; Keywan Riahi et al., “Mitigation Pathways Compatible with Long-term Goals,” in Climate Change 2022: Mitigation of Climate Change, ed. P.R. Shukla and J. Skea (Cambridge, UK: Intergovernmental Panel on Climate Change, 2022), 295-408; Whitney Jones et al., The Landscape of Carbon Dioxide Removal and US Policies to Scale Solutions (New York, NY: Rhodium Group, 2024), https://rhg.com/research/carbon-dioxide-removal-us-policy.

ABOUT THE ECR WORKING GROUP

This ECR working group convenes leading companies across the technology ecosystem, including DAC companies, BiCRS companies, corporate buyers, financiers, supporting infrastructure developers, technology providers, and other key stakeholders (see **Figure 2**). Our discussions with working group members revealed that some of the most significant obstacles to sector growth are related to project financing and market demand. Over the past year, the working group met regularly to build a shared knowledge base of the key market dynamics impacting the ECR industry and to align on a set of policy priorities for enabling market growth.

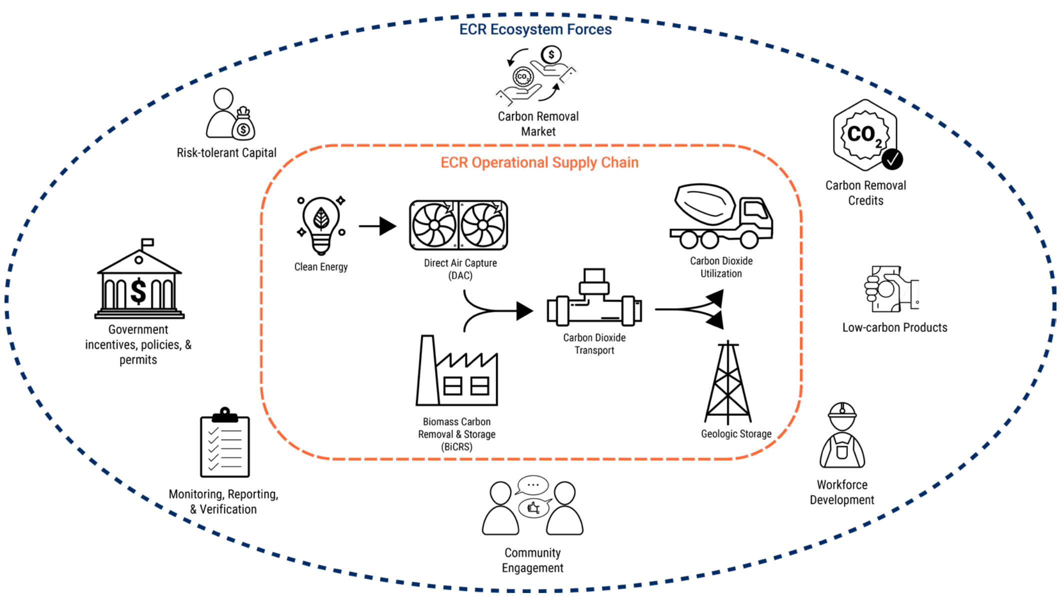
Through member presentations and interactive discussions, the working group examined a range of topics, including ECR project finance and bankability, corporate offtake strategy for carbon removal, and the role of public procurement in accelerating private sector innovation and demand for CDR. Informed by working group discussions, as well as members of C2ES's Business Environmental Leadership Council (BELC), C2ES produced a shortlist of high-impact federal policy recommendations.

ON INNOVATION

Policymakers can play a central role in accelerating innovation across the nascent ECR industry by using a holistic policy framework that encourages rapid deployment of new, innovative technologies. This involves developing policies that support the full innovation cycle—from discovery and testing all the way through full-scale deployment—and by threading the needle between multiple complex dynamics: balancing supply- and demand-side incentives that will grow the ECR market, providing broad support across a range of different technology types and technological maturity levels to encourage innovation, and addressing the principle risks that may inhibit or slow private investment in development and deployment of ECR technologies. During the first year of our ECR working group, we explored these market and finance dynamics in detail.

C2ES will continue to build on this work, integrating learnings from other technology working groups (i.e., long-duration energy storage, sustainable aviation fuels, and clean hydrogen), and helping to align each technology ecosystem around a vision for innovation that can effectively and responsibly speed the commercial deployment of this critical set of technologies.

FIGURE 2: The Engineered Carbon Removal Ecosystem



OVERVIEW OF POLICY RECOMMENDATIONS

The working group's first-year recommendations are focused on specific actions the federal government can take to address known markets and finance barriers to scaling ECR and fall into three broad categories: early project financing, derisking investment, and creating market certainty. **Table 1** summarizes the legislative and administrative policy priorities outlined in this brief.

TABLE 1: Summary of Policy Priorities

CATEGORY	POLICY PRIORITY	LEAD
Early Project Financing	1. Increase program direction budget to fund staffing in key DOE offices	L
	2. Adjust section 45Q tax credit for inflation	L
Derisking	3. Require that all Class VI wells have an associated long-term MRV trust	L
Creating Market Certainty	4. Develop a federal procurement program with increasing tonnage requirements	L
	5. Create a federal economy-wide price on carbon with credits for emissions removals	L A

The column labelled "lead" indicates whether the policy falls under legislative L and/or administrative A purview.

1. INCREASE PROGRAM DIRECTION BUDGET TO FUND STAFFING IN KEY DOE OFFICES

SUMMARY

Congress should increase the U.S. Department of Energy (DOE) program direction budget in the Office of Fossil Energy and Carbon Management (FECM) and the Office of Clean Energy Demonstrations (OCED). These offices are responsible for administering and disbursing funds appropriated for the development and scaling of ECR technologies. The timely awarding and disbursement of funds to well-vetted projects with high probabilities of success is critical to maximizing the climatic and economic benefits of the United States' historic investments in ECR. This can only be accomplished if the departments responsible for such disbursement are adequately staffed with the experts needed to negotiate awards, assess technologies, and aid with implementation challenges.

FECM and OCED have requested a net $82 million increase in their program direction budget in fiscal year 2025, relative to fiscal years 2023 and 2024, for the purposes of increasing fulltime staff and support services from qualified contractors.[5] These funds could be appropriated through additional funding from Congress. Alternatively, Congress could amend the Infrastructure Investment and Jobs Act (IIJA) to increase the allotment of program direction funds from five percent of project spending to six percent.[6]

RATIONALE

Congress has made several key investments to help develop and scale ECR technologies and has supported those investments through increased staffing in DOE departments overseeing carbon management-related funding allocation. This includes creating OCED in 2021 and growing FECM's budget by 12 percent since 2021, when carbon management was integrated into its scope of responsibility.[7] Staffers within these departments have worked rapidly to stand up a suite of initiatives that support the development and commercialization of ECR innovations like DAC and BiCRS, mostly through the $12.8 billion of IIJA funding allocated in 2021 to support early deployment of carbon capture, utilization, and storage (CCUS) projects (including ECR).

Despite these efforts, as of June 2024, of the more than $9 billion of carbon management-related funds made available from the IIJA and the Energy Act of 2020, only half ($4.5 billion) has been awarded.[8] Of those funds that have been awarded, less than $300 million has actually been obligated to projects through completed funding negotiations.[9] DOE programs critical to the scaling of ECR—such as the CarbonSafe Initiative (which predates the IIJA), the CDR Purchase Pilot Prize, and the Regional Direct Air Capture Hubs Program (DAC Hubs)—are particularly sensitive to these administrative shortfalls. They have all seen delays in contract announcements and award negotiations, in some cases by more than a year.[10] Recent examples include the delayed announcement of phase one semifinalists of the CDR Purchase Pilot Prize, which was postponed from mid-February 2024 to late-May 2024, and months-long contract negotiations for DAC Hubs projects, which were selected in August 2023 but have not yet all been finalized.[11] Such delays not only jeopardize the United States' ability to remain a global leader in ECR innovation and reach gigaton-scale carbon removal by mid-century, but they can also imperil early-stage companies that depend on the timely receipt of awarded federal funding to commercialize and grow their operations. Without sufficient technical staff to manage federal programs, these delays will continue, and project deployment will continue to stall.

INNOVATION LENS

Increasing the DOE's program direction budget will ensure the timely and effective management of DOE programs that are helping accelerate innovation for ECR technologies at different maturity levels. Programs that will benefit from this include the DAC Hubs, which are designed to facilitate the commercial-scale deployment of DAC projects, as well as programs like FECM's $100 million in funding for pilot-scale testing of advanced CDR technologies like BiCRS.[12] This recommendation will be particularly helpful to early-stage companies, regardless of their technological focus, that depend heavily on the timely receipt of awarded federal funding to launch or sustain their research, development, or operations.

IMPLEMENTATION

Funding from the IIJA will be made available until fiscal year 2026, and the DOE is responsible for administrating all energy-related funds until they are expended.[13] Thus, the DOE has an acute need to recruit staff with sufficient technical knowledge to assess applications and support awarded projects, but for relatively short contract periods. Tour-of-service programs like the Federation of American Scientists' Impact Fellowship—a program that allows individuals with scientific or technical expertise to support the DOE's work for one- or two-year terms—could address this need without requiring permanent growth in the DOE's fulltime staff.[14] These programs have parallels in academia, in the form of visiting or sabbatical fellowships, and offer excellent opportunities for knowledge-sharing and creating talent pools for long-term employment opportunities, while at the same time meeting the DOE's immediate programmatic needs.

Congress should appropriate funds to meet the project direction requests of the FECM and OCED so that they may recruit the necessary staff. Such funds may be derived from appropriations that are additional to the 2024 fiscal year budget, or by amending the IIJA to allow up to six percent of funds to be used for program direction. Program direction is currently limited to five percent of IIJA funds, raised in 2024 from an original limit of three percent.[15] An additional increase of one percent of the $12.8 billion of IIJA funding earmarked for carbon management would fund FECM and OCED's requested project direction budget increase for carbon management-relevant IIJA programs for the next three years, helping grow the impact of remaining IIJA funds by ensuring they are distributed sooner rather than later.[16]

2. ADJUST SECTION 45Q TAX CREDIT FOR INFLATION

SUMMARY

Congress should modify the section 45Q tax credit for carbon dioxide sequestration, specifically by making the inflation adjustment of the tax credit effective in 2024 (rather than in 2027, as in the statute), with 2022 as the base year. Inflation has already eroded the value of the 45Q tax credit since it was increased by Congress in 2022. Adjusting the tax credit for inflation starting in 2024 is critical to ensuring that it can effectively deliver support for the nascent ECR industry for the credit period that Congress intended.

RATIONALE

The 2022 Inflation Reduction Act (IRA) increased the value of the section 45Q tax credit to $85 per metric ton of fully qualified carbon dioxide storage and $180 per metric ton for DAC.[17] This adjustment was transformative in creating a financially feasible pathway for scaling CCUS projects (including ECR). However, the 45Q credit is not eligible for inflation adjustment until 2027, with 2025 being the base year for adjustment.

As the result of higher-than-anticipated inflation since the passage of the IRA, the effective value of the 45Q credit has diminished by nearly 11 percent from 2022 to 2024, for a per metric ton effective value of $77 ($163 for DAC) in 2024.[18] Even if U.S. inflation stabilizes to the more modest annual rate projected by the Congressional Budget Office and International Monetary Fund of two percent in 2025 and 2026, the effective value of the 45Q credit will be $74 ($157 for DAC) per metric ton—only 87 percent of its original value—for the remaining eight years of the credit lifespan.[19]

For those sectors in which the capture of carbon dioxide is more expensive because it must be extracted from more dilute gas streams (e.g., bioenergy with carbon capture and storage (BECCS), BiCRS, DAC, hydrogen production, fossil-based power generation), estimated costs of capture and storage range from $50 to several hundred dollars.[20] For some of these projects, the decreased effective value of the 45Q tax credit could be the difference between financial viability and the need to secure secondary financing. If the latter is necessary, this could slow (and potentially eliminate) project development. The C2ES ECR technology working group is not alone in raising this risk: the Carbon Capture Coalition—of which C2ES is a member—has also articulated a strong rationale for a 45Q inflation adjustment.[21]

To address this issue, section 45Q should be amended to adjust for inflation effective 2024, assessed from a base year of 2022. Such inflation adjustment is comparable to other tax credits in the IRA, such as the clean electricity production tax credit 45Y and the clean hydrogen production tax credit 45V.[22]

INNOVATION LENS

Adjusting 45Q for inflation is necessary for the credit to continue to effectively support the early deployment of ECR technologies in the face of changing macroeconomic conditions. The qualifying threshold of at least 1,000 metric tons of carbon dioxide per year means this adjustment would most likely benefit pilot, demonstration, and commercial-scale projects. Pairing inflation adjustment of 45Q with additional policy for more emerging ECR technologies can ensure the government is actively supporting innovation across the full spectrum of potential solutions.

IMPLEMENTATION

Adjusting the section 45Q tax credit to account for inflation will require an act of Congress. To effectively implement this policy solution, Congress should pass an amendment in 45Q(b)(1)(A), substituting “2024” for “2027,” “2023” for “2026,” and “2022” for “2025.” The 45Q tax credit has already been amended multiple times since its introduction in 2008 to ensure it serves its intended purpose.[23]

3. REQUIRE THAT ALL CLASS VI WELLS HAVE AN ASSOCIATED LONG-TERM MRV TRUST

SUMMARY

Congress should establish a long-term monitoring, reporting, and verification (MRV) trust for all Class VI wells to ensure responsible stewardship. Class VI wells are used for the subsurface injection of carbon dioxide for the purpose of permanent sequestration and are regulated by the U.S. Environmental Protection Agency (EPA) under the Safe Drinking Water Act.[24] The trust would be modeled after the Leaking Underground Storage Tank (LUST) trust fund.[25] It would be funded by users of Class VI wells, who would pay a small fee per metric ton of sequestered carbon dioxide.

The fund would serve two purposes:

1. to finance the administration of active projects by the EPA (or equivalent state authority for states granted primacy over Class VI wells), thus ensuring sufficient regulatory oversight of active carbon sequestration projects
2. to finance long-term stewardship of Class VI wells by the EPA (or equivalent state authority).

Long-term stewardship financed by the fund would primarily involve post-closure monitoring of stored carbon dioxide. It would also serve as an emergency fund to address or remediate damages in the unlikely event of storage reversal after the expiration of operator liability (whether that expiration occurs through state or federal adoption of liability, or because the operator has ceased to exist).

Like the LUST trust fund, the U.S. Department of the Treasury would be responsible for managing the Class VI MRV trust. This would include accepting fees collected by the EPA or state authority (for states granted primacy over Class VI wells), distributing funds for MRV and in the unlikely event of remediation, and investing receipts credited to the fund following Department of Treasury fiscal investment policy guidelines.[26] During the operational lifetime of the well, the MRV trust fee would be regularly assessed to ensure funds are sufficient to meet the goals of the trust. For states that have their own MRV or long-term liability fee, the federal fee would be waived if the state fee for a trust is at least equivalent or greater than the federal fee.

RATIONALE

Scientists estimate that the likelihood of carbon dioxide retention in suitable geologic storage reservoirs is greater than 99 percent over thousand-year timescales.[27] While the risk of carbon dioxide leakage from geologic reservoirs is low, addressing perceived risk and being prepared for a low-probability leakage event is critical to the success of long-term carbon sequestration projects. Existing opposition to carbon storage projects with geologic sequestration is in large part based on a lack of transparency regarding how projects are monitored and audited by the EPA or equivalent state authority, as well as the discrepancy between project lifetimes (on the scale of a few decades) and the intended sequestration time of carbon in the subsurface (on the scale of hundreds to thousands of years).[28] Such opposition can delay or even lead to the cancellation of projects, reducing the industry's ability to scale as a whole and threatening emerging companies that are transitioning from pilot stage to commercial-scale sequestration.[29]

In addition to the perceived long-term risks of leakage by the broader public, the prospect of financing and insuring a project that has indefinite liability for environmental damages is challenging and could deter investors from pursuing scale-up opportunities in ECR or related carbon management activities.[30] This has led several states to assume liability for long-term carbon storage (see **Table 2**), although such a solution comes with its own challenges. First, public assumption of post-closure well liability could disincentivize private operators from engaging in responsible site selection, operation, and closure of wells.[31] Second, it could burden taxpayers with the cost of long-term MRV and potential remediation. There is a need for a policy mechanism that releases carbon storage companies from indefinite financial responsibility after the period of highest risk for storage reversal while ensuring the financing burden of long-term monitoring and liability does not fall on taxpayers.

States with their own MRV trusts finance them with a small, fixed per metric ton storage fee, which is either decided by the regulating authority or set by legislative rule. For instance, Indiana's fee is included in state law and is $0.08 per metric ton of stored carbon dioxide.[32] This is consistent with published estimates of the cost of monitoring geologic storage over a project's full life cycle

TABLE 2: State Programs for Carbon Storage MRV Trusts

STATE	FEE AMOUNT FOR STATE MRV FUND	POST-CLOSURE PERIOD BEFORE LIABILITY ADOPTION BY STATE
Indiana[1]	$0.08 per ton of CO_2 sequestered for all CCS projects operating within the state, used exclusively for long-term monitoring and management of a carbon sequestration project	0 years after injection has ceased, and a certificate of completion has been issued
North Dakota[2]	$0.01 per ton of carbon dioxide injected for storage to be deposited in an administrative fund; $0.07 per ton to be deposited in the carbon dioxide storage facility trust fund	10 years after injection has ceased, and a certificate of completion has been issued
West Virginia[3]	Amount not defined; a per ton fee determined by legislative rule, and to be reassessed every 4 years	10 years after injection has ceased, and a certificate of completion has been issued
Wyoming[4]	$0.07 per ton of carbon dioxide sequestered; fund consists of monies collected in "an amount reasonably calculated to pay the costs of measuring, monitoring and verifying [geologic sequestration] sites"	20 years after injection has ceased, and a certificate of completion has been issued; liability is capped at the amount that is the balance of the state's geologic sequestration special revenue account
Louisiana[5]	A per ton fee that will accrue until the fund is $5 million for a single storage facility, or $10 million for a single storage operator; to be reassessed annually, based on the estimated cost of administering and enforcing regulations divided by expected tonnage of CO_2 injection during the fiscal year	50 years after injection has ceased (with site-specific exceptions allowed), and a certificate of completion has been issued; release from liability is only within the limits of the state's geologic storage trust fund (last owner or operator is liable for expenses in excess of this fund)
Montana[6]	Amount not defined; a per ton fee determined by the Montana Board of Oil and Gas Conservation, based on anticipated actual expenses to monitor and manage geologic storage reservoirs during post-closure phases	25 years after injection has ceased, a certificate of completion can be issued, but operators must provide adequate bond or other surety and retain liability for an additional 25 years
Texas[7]	Fees collected by the Texas Railroad Commission for permitting, monitoring, inspecting carbon dioxide injection wells and enforcement of regulations (does not include liability coverage)	No state liability
Kansas[8]	Amount not defined; fees collected 'for permitting, monitoring, and inspecting operators of carbon dioxide injection wells and underground storage'	No state liability

Source: Nixon Peabody, "States Look to Attract CCS Projects Through Laws Shifting Long Term CO2 Storage Liabilities," May 2, 2022, https://www.nixonpeabody.com/insights/articles/2022/05/02/states-look-to-attract-ccs-projects-through-laws-shifting-long-term-co2-storage-liabilities; Ohio River Valley Institute, "Carbon Storage Liability Transfer and Pore Space Unitization: Statute Survey and Background," accessed July 8, 2024, https://centerforcoalfieldjustice.org/wp-content/uploads/2024/02/Carbon-Storage-Liability-Transfer-Pore-Space-Unitization_-Statute-Survey-and-Background-1.pdf.

($0.05–0.10 per metric ton of carbon dioxide).[33] However, both the fees and the post-closure period of operator liability varies across states, and some states in which Class VI well applications have been submitted have no policies in place.[34]

Establishing a federal MRV trust fund would complement, expand, and harmonize state-level policy efforts across states in which the burgeoning ECR industry operates. Additionally, it would help alleviate community concerns regarding the long-term monitoring, stewardship, and potential remediation of a project well beyond its initial deployment.

There is precedent for developing federal monitoring and liability trusts through usage fees for other hazardous materials. These could serve as a model for developing a federal MRV trust program for carbon storage. These include the LUST trust fund, as well as other programs such as the Oil Spill Liability fund and Superfund program, summarized in **Table 3.** As a particular example, the LUST trust fund was first established in 1986 to regulate underground storage tanks, address petroleum releases, and fund leak-prevention activities.[35] It is funded by a 0.1 cent per gallon tax on motor fuel. Since its implementation, 90 percent of identified releases have been cleaned up, and the number of new releases identified annually have declined from an average of 32,000 in the 1990s to less than 5,000 each year since 2000.[36] In recent years, the LUST trust fund has had significant surpluses, due to interest accrual exceeding annual expenditures, causing Congress to authorize transfers from the trust fund to help finance other revenue gaps, specifically in funding highways and public transportation.[37] If an excess of funds were to accrue in a Class VI MRV trust, they could similarly be evaluated by Congress for transfer to other legislative priorities, on condition that sufficient funds remain available to serve the intended purpose of the trust.

INNOVATION LENS

Requiring that all Class VI wells have an associated long-term MRV trust should mitigate risks that are dampening the long-term demand signal for ECR by helping to standardize best practices and strengthening the entire industry's social license to operate. In the near-term, this should increase financier confidence at the critical juncture where projects begin putting steel in the ground (i.e., moving from the lab into first-of-a-kind demonstration). When evaluating whether a new technology is bankable, investors and lenders are principally concerned with whether the project is appropriately derisked and has sufficient creditworthy customers. Enacting this policy recommendation should help address both perceived and actual technological and social risks of ECR projects. This will support innovation by giving investors, communities, and operators greater confidence in the responsible deployment of ECR.

IMPLEMENTATION

Congress should establish a federal MRV trust for Class VI wells and authorize EPA (or the relevant state agency for states with primacy) to use it to address short- and long-term monitoring and long-term stewardship of storage projects. Mirroring the protocols developed for the LUST trust fund, the EPA (or the relevant state agency)

TABLE 3: Comparable Trust Funds

TRUST FUND	SUMMARY
Oil Spill Liability Trust Fund[9]	Part of the 1990 Oil Pollution Act, this $1-billion fund is financed by a tax on oil and used to pay for cleanup costs for oil spills that exceed the liability limit.
Hazardous Substance Response Trust (Superfund)[10]	Part of the 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), this fund is financed through taxes, cost recoveries, fines, and penalties, and is used to finance environmental emergency responses and hazardous waste cleanups.
LUST Trust Fund[11]	In 1986, Congress amended Subtitle I of the Solid Waste Disposal Act, to create the LUST Trust Fund. The fund is used to enforce, oversee, or (when the owner or operator is unknown) carry out cleanups of petroleum releases from federally regulated underground storage tanks. It is financed by a 0.1¢ tax on each gallon of motor fuel sold nationwide.

Source: Muriel Hague, "A Hitchhiker's Guide to Carbon Capture and Sequestration Regulation in Texas and Beyond," Houston Law Review 61.4 (April 29, 2024), https://houstonlawreview.org/article/117181-a-hitchhiker-s-guide-to-carbon-capture-and-sequestration-regulation-in-texas-and-beyond; "Leaking Underground Storage Tank Trust Fund," U.S. Environmental Protection Agency, updated May 20, 2024, https://www.epa.gov/ust/leaking-underground-storage-tank-trust-fund.

would administer fee collection and funds disbursement for MRV or mitigation activities via transfers to and from the fund, which would be managed by the U.S. Department of the Treasury.[38] The fund would be financed by well operators at a fixed fee per metric ton of carbon dioxide sequestered, consistent with the estimated lifetime costs of storage monitoring. For states with their own MRV or liability fund fee, the federal fund would only collect the difference between the state and federal fee (or nothing, in the event that the state fee is higher). During the lifespan of a given Class VI project, the fund would finance EPA's (or the relevant state agency's) administration of the project and its oversight of MRV reporting to the EPA's Greenhouse Gas Reporting tool.[39]

In terms of liability, the risk of leakage in a carbon storage project is highest during injection, and for a length of time approximately equal to the injection period after injection has ceased.[40] Thus, operators should be required to retain ownership and full liability for the storage site for a specified period after injection has ceased, which should mirror the EPA's (or relevant state authority's) regulation for the post-injection site care period. Currently, EPA issues a site closure certificate to a Class VI well operator 50 years after the cessation of carbon injection, although the EPA site administrator has the discretion to approve a shorter post-injection site care period if it is demonstrated that the project does not pose a risk to underground drinking water.[41] After this period, monitoring ceases indefinitely. The MRV trust would fund periodic monitoring of the site post-closure and would cover any storage reversal mitigation costs that are beyond the scope of operator liability, or in cases where the operator no longer exists.[42]

4. DEVELOP A FEDERAL PROCUREMENT PROGRAM WITH INCREASING TONNAGE REQUIREMENTS

SUMMARY

The U.S. federal government should establish a long-term federal carbon dioxide procurement policy, with a time horizon of at least ten years, to support the development and scale up of novel carbon removal technologies. The policy should take a portfolio approach across a set of CDR categories, comparable to those laid out in the CDR Purchase Pilot Prize (i.e., DAC, BiCRS, enhanced geological weathering or mineralization, and alternative planned or managed carbon sinks).[43] Within each category, offtake contracts would be awarded via a reverse auction—where CDR sellers bid for government contracts by offering the lowest price—with a maximum price per net metric ton of carbon dioxide to incentivize least-cost innovations. Moreover, federal procurement should adhere to the government's recently announced Principles for Responsible Participation in Voluntary Carbon Markets, serving as a model for responsible CDR procurement.[44] Such a portfolio approach would help accelerate innovation, provide demand certainty, and enable greater price discovery and transparency. The insights gained from this policy could also contribute to a broader, long-term strategy aimed at reducing the federal government's carbon footprint and ultimately achieving net negative emissions through the procurement of ECR.

RATIONALE

Government procurement and long-term offtake agreements are some of the most influential levers for scaling nascent clean energy technologies. Since the 1990s, federal policies have directed the purchasing of energy-efficient products, which the EPA's Energy Star program helped identify. This policy helped grow the market of energy-efficient products by making them more affordable and more widely available, and by strengthening public awareness of the value of energy efficiency.[45] More recently, the 2021 Federal Buy Clean Initiative began promoting the use of low-carbon construction materials.[46] Since its announcement, the initiative has incentivized more than 17,000 manufacturers to publish environmental product declarations so that they can be competitive for federally-funded construction projects.[47]

In the case of ECR, the CDR Purchase Pilot Prize is historic in that it is the first direct CDR purchase by the U.S. federal government. Only three other countries have formal CDR purchasing commitments: Sweden, Denmark, and Canada. The latter two countries announced their commitments in April 2024, months after the CDR Purchase Pilot Prize announcement.[48] Combined with CDR investment from the IIJA and the section 45Q tax credit, the prize establishes the United States as a global leader in supporting the technological development of CDR. It also sets an example for responsible carbon removal that will drive momentum in the voluntary carbon market, as evidenced by Google's pledge to match the $35 million CDR Purchase Pilot Prize initiative over the next year.[49]

However, the CDR Purchase Pilot Prize has limitations. The prize's 36-month timeframe is too short and does not establish long-term market stability, which is critical to encouraging investment in high-capital projects.[50] The short delivery timeline also precludes early-stage developers from participating. A longer-term federal carbon removal procurement strategy, such as the one proposed in the Federal Carbon Dioxide Removal Leadership Act of 2024, would build on the benchmarks for high-quality CDR projects that the CDR Purchase Pilot Prize establishes, while addressing these shortcomings.[51] The other form of federal support for CDR—the section 45Q tax credit—also has limitations: it is not technology-neutral and therefore favors specific ECR technologies. A federal procurement portfolio across various CDR verticals can effectively address these gaps.

A federal procurement portfolio for ECR implemented through a reverse auction could also lay the groundwork for a more permanent policy approach. Given the need to scale and sustain gigaton-level removals and the fact that CDR is a pure public good—meaning it benefits all of society, not just the party who pays for the removal—direct large-scale purchasing of carbon removal by the public sector may be needed. Indeed, a number of observers have characterized CDR as a form of waste management that should be funded much like sewage disposal or municipal garbage collection.[52] A federal CDR procurement portfolio, comprising a wide range of technologies, could produce a wealth of information and learnings to inform such an approach.

INNOVATION LENS

Federal procurement has a long track record as an effective policy tool that fosters innovation. In addition to encouraging competition between innovators, federal procurement also provides the validation necessary to catalyze private-sector demand for new technologies. In the case of ECR, the knowledge that would flow from a long-term, portfolio-based procurement program should incentivize a spectrum of ECR technologies, including those in the early-stages of development. Distinct reverse auctions in the categories of DAC, BiCRS, enhanced geological weathering or mineralization, and alternative planned or managed carbon sinks should ensure that these approaches compete with their peers rather than different technology types. This can mitigate the risk of more developed technologies crowding out promising—yet nascent—approaches. Even still, a reverse auction will most likely benefit technologies already producing carbon removal credits, which may reveal a need to further segment the portfolio by maturity in addition to technology category.

IMPLEMENTATION

Congress would need to enact a long-term federal procurement policy. It could leverage a portion of the capital appropriated for the continuation of the CDR Purchase Prize. In the long term, a procurement program could be financed through a price on carbon (see Recommendation 5). It would require the annual purchase of a growing minimum tonnage of carbon removals, for a period of not less than ten years. To encourage responsible deployment of CDR, and to ensure that procurement supports more advanced technologies while cultivating the potential of nascent ones, the procurement portfolio should:

- include multiple different CDR categories that can compete amongst their technological peers for least-cost innovation
- establish distinct reverse auctions for each carbon removal vertical and set an annual maximum per-ton purchase price that decreases with time
- require that all purchased carbon removals adhere to all Principles for Responsible Participation in Voluntary Carbon Markets, as they apply to credit-generating activities.[53]

5. WORK TOWARD A FEDERAL ECONOMY-WIDE PRICE ON CARBON

SUMMARY

The administration and Congress should examine options and work toward enacting an economy-wide market-based carbon reduction program that could contribute to the achievement of net-zero emissions by 2050. Setting a price on carbon—whether through a carbon tax or a cap-and-invest program—confers a clear market value to emissions reductions and emissions removals that is commensurate with the environmental, societal, and economic benefits that reducing global greenhouse gas pollution provides. The carbon pricing program could be designed to credit verified carbon dioxide removals (including through ECR), and revenues from the program could be used to pay for lowering government deficits, reducing distortionary taxes, or to foster technology innovation (e.g., additional carbon management programs).

RATIONALE

One of the most significant obstacles to scaling up innovation and deployment of any form of CDR is the absence of market demand. Removing carbon dioxide from the atmosphere is a type of public good: it benefits all of society, not just the economic actor who pays for the removal. Put differently, the private willingness-to-pay for CDR is far lower than the societal value. Policies such as the 45Q tax credit and federal procurement program seek to substitute government payments for this “missing demand,” but require substantial outlays of public funds. A price on carbon could provide the demand signal needed to encourage deployment of CDR, build investor confidence in the value of CDR solutions, and generate revenue for the government.

An economy-wide carbon price would have benefits beyond developing demand for CDR. Market-based policies can drive innovation and can more cost-effectively reduce emissions than traditional regulations by giving emitters the flexibility to find the lowest-cost options for reductions.[54] For example, a cap-and-trade program enacted in 1990 for the reduction of sulfur dioxide emissions—the primary cause of acid rain—resulted in a rate of emissions reductions that doubled what was predicted from traditional regulation.[55] In terms of carbon pricing, the world’s first national carbon tax in Finland is estimated to have reduced carbon emissions 30 percent faster within its first 15 years of existence than a scenario where carbon pricing had not been enacted.[56]

High-integrity CDR approaches could be included in a carbon pricing policy by providing a tax credit or tradeable allowance for each verified metric ton of carbon dioxide that is removed from the atmosphere and permanently sequestered. Absent a very high initial carbon price, most forms of ECR will likely be too expensive in the near term to be competitive with other types of emissions reductions. The most cost-effective strategies for emitters would likely be to reduce their emissions through other means such as increasing efficiency, switching to carbon-free power generation, or adopting lower-emitting industrial practices and technologies. Nonetheless, a durable price signal—in combination with other policies already in place and those proposed here—will encourage innovation in new technologies (including CDR) to lower emissions and assure early actors in the ECR market that long-term demand exists.

As the carbon price increases with time and the capacity of other emission reductions strategies are exhausted, ECR will become an increasingly important solution. Designed thoughtfully, a carbon pricing policy could help the ECR market grow, so it is ready when needed. For example, a portion of revenues generated by a carbon pricing program could be used to offset other federally funded carbon management programs, such as research and development grants that would help drive down the cost of ECR and related technologies or a federal carbon removal procurement program (see Recommendation 4). It could also be used for other purposes such as lowering government deficits or reducing distortionary taxes.

INNOVATION LENS

A carbon price would strengthen existing and future prospective policies aimed at accelerating the deployment of ECR technologies, as well as other emerging low-carbon technologies. While it will take time before carbon removal credits could be the most cost-effective way to comply with a carbon price, the demand signal it creates will be crucial to achieve the gigaton-scale carbon removal targets necessary to meet long-term climate goals.

IMPLEMENTATION

The administration and Congress should examine options and work toward enacting an economy-wide market-based carbon reduction program that could contribute to the achievement of net-zero emissions by 2050. Work on such a program should include conducting analyses, developing policy principles, drafting legislation, conducting workshop discussions, and holding committee hearings. In the case of a carbon tax, measurable forms of CDR can be incorporated into carbon pricing through carbon removal credits (or crediting). In the case of a cap-and-trade (i.e., cap-and-invest) system, they could be made available as a tradeable unit of emission reductions (or allowances).

Most of the carbon tax proposals introduced in the last two Congresses include crediting or a refund for the amount of carbon dioxide emissions captured, sequestered, or utilized from combustion of covered fuels.[57] Conceivably this could cover measurable and durable carbon removal technologies, such as DAC and BiCRS. Following the U.S. Supreme Court overruling the Chevron doctrine, congressional proposals should directly address whether carbon removal technologies should be credited.[58]

CONCLUSION

The U.S. federal government has demonstrated a commitment to meeting gigaton-scale carbon dioxide removal by mid-century. Initiatives like the CarbonSafe program, the DAC Hubs program, the CDR Purchase Pilot Prize, the section 45Q tax credit—and many others made possible through the IIJA and IRA—are foundational to enabling the evolution of engineered carbon removal through the full innovation cycle, from lab-scale ideation to commercial-scale deployment. Continuous improvement of existing programs and thoughtful additions of new initiatives will be critical to ensuring that federal policy continues to comprehensively and durably support the entire CDR industry, including engineered carbon removal. The policy recommendations offered in this brief were developed through discussions with stakeholders across the engineered carbon removal ecosystem and offer a potential path forward in the pursuit of this objective. Ensuring (1) that federal offices have sufficient personnel to effectively execute on their programs; (2) that 45Q tax credit is adjusted for inflation; (3) that all Class VI wells have an associated long-term MRV trust; (4) the establishment of a federal CDR procurement program with increasing tonnage requirements; and (5) the implementation of a federal economy-wide price on carbon inclusive of carbon removal credits will all contribute to the establishment of engineered carbon removal as an effective piece of the broader decarbonization puzzle.

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A company's participation does not represent an endorsement of the full contents of this brief. As a fully independent organization, C2ES is solely responsible for its positions, programs, and publications.

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Additional Resources

The Power of Procurement: Scaling the Carbon Dioxide Removal Market (Blog)
https://www.c2es.org/2024/05/the-power-of-procurement-scaling-the-carbon-dioxide-removal-market/

Engineered Carbon Dioxide Removal: Scalability and Durability (Brief):
https://www.c2es.org/document/engineered-carbon-dioxide-removal-scalability-and-durability/

Carbon Dioxide Removal: Pathways and Policy Needs (Brief)
https://www.c2es.org/document/carbon-dioxide-removal-pathways-and-policy-needs/

Engineered Carbon Removal Working Group (Webpage)
https://www.c2es.org/accelerating-the-us-net-zero-transition/c2es-technology-working-groups/engineered-carbon-removal-working-group/

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