Procurement As A Catalyzing Federal Instrument For Carbon Dioxide Removal

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Executive Summary

Carbon dioxide removal (CDR) solutions refer to technologies, practices and approaches that remove carbon dioxide from the atmosphere and sequester it. While carbon dioxide is not toxic as we breathe it in and out every day, too much of it can cause problems. As the world has industrialized, carbon dioxide has also seeped into the atmosphere. While there are many breakthrough energy and manufacturing technologies being deployed to reduce emissions, we still must deal with what's already out there. Due to the challenge of completely decarbonizing some industrial sectors, such as aviation, shipping and industrial processes, the International Energy Agency (IEA) states that CDR is essential for achieving emissions reduction goals.[1,2]

This report presents the case for a competitive federal procurement program to catalyze wide-scale commercialization of CDR solutions. This report reviews purchasing mechanisms that the U.S. federal government has historically used to develop ground-breaking innovations; summarizes existing federal policies and private sector activities in CDR to highlight the opportunity for a federal procurement program to accelerate commercialization; and describes pathways for achieving a cost-effective, innovation-focused federal procurement program. Major takeaways from this report include:

1. Previous Federal Procurement Initiatives Have Propelled U.S. Leadership in Innovation.

U.S. leadership in technological innovations in computing and pharmaceuticals demonstrates the effectiveness of using competitive federal procurement to bridge the gap between early-stage scientific research to commercialization. This model should be followed for quality CDR solutions that sequester and store carbon dioxide from the atmosphere and are in the earliest stages of research and development (R&D). Using federal procurement in this manner is aligned with federal priorities for driving innovations in quality CDR solutions that further decarbonization goals.

2. Federal Investments in Private Sector Solutions for CDR Innovation are Essential for Decarbonization.

By mid-century, the U.S. may need to remove 2 billion metric tons of carbon dioxide annually to reach stated emission reduction goals.[3] Recent bipartisan legislation and appropriations have provided over $12 billion in investments for the nascent carbon management industry. This has stimulated an unprecedented volume of private-sector CDR purchasing agreements over the past few years. However, complementary and continued federal policies are essential for commercializing CDR solutions at the scale and pace necessary.

3. A Reverse Auction is the Most Cost Effective Catalyst for CDR Commercialization.

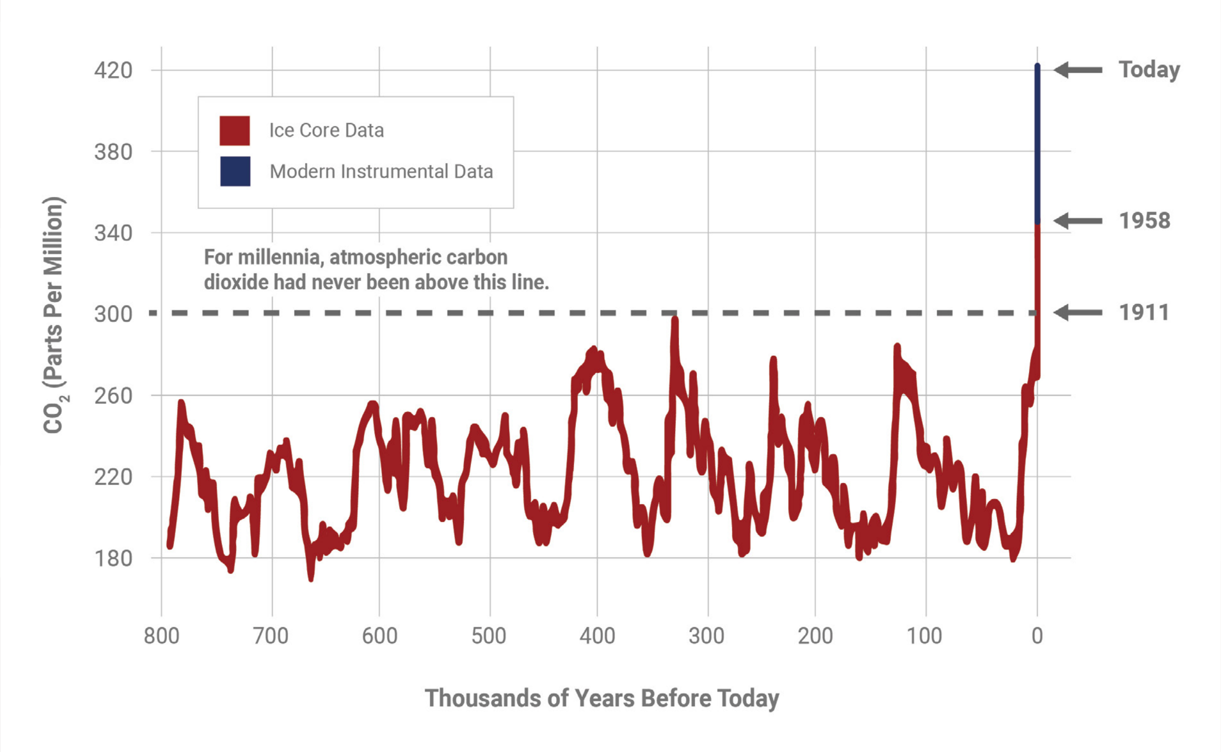
Competition fosters innovation and efficiency in a way few other mechanisms can match, driving cost reduction and scalability in the CDR sector. Reverse auctions invite suppliers to compete in offering buyers a product or service at the lowest cost or most favorable terms, unlike traditional procurement methods where buyers set a fixed price. Combining the forces of private sector ingenuity, market competition, and metrics for quality CDR solutions is the optimal approach for catalyzing the carbon removal industry.

1. Introduction

The Problem

Carbon dioxide is a heat-trapping gas, also known as a greenhouse gas, that is produced from natural processes like volcanic eruptions and wildfires and the extraction and burning of fuels like coal and natural gas to manufacture goods and produce electricity as well as agricultural practices. Since the 18th century, atmospheric concentrations of carbon dioxide have increased by 50% – meaning the amount of carbon dioxide in the atmosphere is now 150% of its value in 1750, shown in Figure 1.[4]

Figure 1. Historical Measurements of Carbon Dioxide.



Source: NASA

Depending on the scale and speed of emissions reduction efforts and residual emissions from difficult-to-decarbonize sectors, the United States will need to remove nearly 2 billion metric tons of carbon dioxide annually by midcentury to reach net zero, and there are currently not enough carbon dioxide removal (CDR) solutions to reach this scale. 2 billion metric tons of carbon dioxide annually is the equivalent of taking 435 million cars off the road in a year or roughly 30% of U.S. 2019 greenhouse gas emissions.[5] Globally, with current models and estimates, CDR would need to reach a scale of 10 billion metric tons by 2050 and double to 20 billion metric tons by 2100.[6]

The Solutions Exist, But They Need to Scale

Private and public sector commitments to reach net-zero emissions by 2050 have rapidly increased. At the end of 2022, more than 4,000 companies, over a third of the global economy's market capitalization – had set targets to reach net zero or reduce their carbon emissions.[7] Some of these companies include Bank of America, Procter and Gamble (P&G), AT&T, PayPal, Walmart, Walt Disney, and PepsiCo. Companies with these commitments want to invest in CDR solutions that clearly measure the amount of carbon dioxide taken out of the atmosphere, effectively avoiding re-releasing into the atmosphere, and having the ability to verify those claims through a third party. These three pillars are known as quantifiable, durable, and verifiable CDR solutions. Despite this increased interest by the private sector, the volume of currently available carbon market solutions being sold is still too limited and are often unregulated, unverifiable and low-quality.[8]

Concurrently, industry leaders that have identified CDR as an essential part of their long-term business strategy, like Duke Energy, Occidental Petroleum, JP Morgan, United Airlines, and Microsoft, have made investments in U.S.-based CDR technologies to stimulate market supply of high-quality CDR services.[9] These investments are essential, but the current supply of deployable, quality carbon removal technologies is still too limited to incentivize significant private-sector investment in new CDR technologies. Therefore, under existing conditions, the U.S. is not on track to deliver CDR at the gigaton scale by midcentury and beyond.

In the long term, being at the forefront of CDR technologies would position America as a global leader, boosting its economy while staying ahead of the game in innovation. A recent report from Boston Consulting Group (BCG) found that one CDR technology alone, Direct Air Capture (DAC), has an international market potential of $1.5 trillion and creates, on average, over 1,200 jobs over the five years it takes to build a DAC facility.[10,11] A robust federal procurement program could be an important piece of the policy puzzle that brings CDR to this scale.

Current U.S. Federal Policies & Resources

There have been significant recent increases in federal investments to advance CDR research, development, and deployment (RD&D) projects following authorizations in the Energy Act of 2020. From receiving almost negligible funding in 2019, CDR R&D funding through the U.S. Department of Energy (DOE) increased to $140 million in FY23. Strong bipartisan support in Congress across multiple years has yielded a tax incentive of up to $180 per metric ton of carbon dioxide for new DAC projects. The Energy Act of 2020 and Bipartisan Infrastructure Law created both a prize and a $3.5 billion Regional DAC hubs program, recently launched by the Department of Energy to catalyze commercial investment and deployment of first-of-a-kind projects.

Federal funding has stimulated follow-on private sector investments and commitments to CDR. Recent project announcements include Occidental's 500,000 metric ton DAC project in the Permian Basin, Texas, with the potential to scale up to 1 million metric tonnes; CarbonCapture Inc.'s 5 million metric ton by 2030 removal project in Sweetwater County, Wyoming; Charm Industrial's Biomass Removal and Storage (BiCRS) process in Colorado and Kansas, which has removed 6,420 metric tons of carbon dioxide to date, and Global Thermostat's 1,000-ton capture project in Commerce City, Colorado.[12,13,14,15] Although these investments are catalytic for the development and demonstration of CDR solutions, achieving decarbonization goals necessitates that more is done to incentivize wide-scale deployment. A competitive federal purchasing program is a cost-effective demand-side policy that can accelerate the commercialization of CDR solutions.

Congress and the administration both see significant value in CDR efforts. Based on direction from Congress, the DOE Office of Fossil Energy and Carbon Management (FECM) recently launched a Purchase Pilot Prize to advance technologies that remove carbon dioxide directly from the atmosphere. The CDR Purchase Pilot Prize will enable companies to compete for the opportunity to sell CDR credits directly to DOE.[16] While this program will help build standards for successful CDR programs, encourage innovation, and grow the industry, it is only an initial sample of what a long-lived, effective carbon dioxide purchasing program could look like.

Theory of Change

The United States benefits immensely from its dynamic, free market economy. Heterogeneity of producers and consumers leads to efficient allocation of capital in achieving economic growth. Within this economy, the transformative power of federal procurement can drive innovation and market growth. Historical procurement of innovation successes underscore the pivotal role that federal procurement plays in kickstarting early demand for emerging technologies and solutions. CDR, a groundbreaking and relatively new product category, would equally benefit from federal procurement. For this reason, publicly supported efforts aimed at stimulating investment in technological innovation can accelerate the uptake of cleaner technology that yields future benefits.

2. Carbon Dioxide Removal

CDR refers to technologies, practices, and approaches that remove carbon dioxide from the atmosphere and sequester it. CDR encompasses a wide range of solutions, including natural solutions such as afforestation and soil carbon sequestration, engineered methods such as DAC, and hybrid solutions such as BiCRS and enhanced rock weathering, that combine natural and engineered technologies.

With increasing private and public sector commitments to reach net-zero emissions by 2050, companies are scrambling to invest in "quality removals", defined as quantifiable, the ability to measure the exact amount of carbon dioxide removed, durable, which is how long the carbon dioxide stays out of the atmosphere, and verifiable, the ability to be verified by third-parties. These quality CDR solutions are necessary to reach 2050 goals. Despite increased interest in carbon removal technologies, market opportunities for carbon removal are still too small to incentivize significant private sector investment in new CDR technologies, and unfortunately, the current stage of development and deployment of these technologies given current demand, is too limited to make a substantial difference, as seen in Table 1. In addition to further research and development of promising technologies, a federal purchasing program with the clear goal of accelerating the innovation of CDR technologies would enhance public-private partnerships and aid in scaling proven carbon removal technologies.

Table 1. Current and Projected CDR Technology Removal Capacity.

			Current Capacity[7]		Announced Capacity (as of Sept 2022)[6,7]	
	CDR Technology	Permanence, years	# Of Projects	Total Capacity, TPA CO_2	# Of Projects	Total Capacity, TPA CO_2
DAC	DAC[1]	>10,000	3	~5K	~70+	7 M
BiCRS	BECCS[2]	>10,000	1	~4K	12+	25M
	Biochar/ bio-oil	Uncertain; depends on use-case, production process; and other factors, but centuries[3]	~35[4]	~65K	~40	~1.9M +
	Biomass-to-hydrogen[5]	>10,000 with geological storage	N/A	Limited publicly available information	3	~8M
Mineralization	Mineralization (ex-situ)	>10,000	N/A	Lab and pilot scale	N/A	Earlier scale projects

Source: U.S. DOE

3. Procurement As A Tool for Game Changing Innovation

Demand-side policies stimulate innovation by creating initial demand and markets for new products, resulting in increased incentives for successful innovation. Examples of demand-side instruments include intellectual property rights, tax credits for new-technology consumers, and public procurement of innovation. Public procurement of innovation is defined as the process by which a public agency purchases or places an order for a product or service that does not yet exist but could be developed within a reasonable time period as a result of additional or new innovative work by the organization willing to produce, supply, and sell the products being purchased. Compared to supply-side policies like government-sponsored R&D grants, public procurement for innovation has a higher degree of conditionality of funding to guide technological development.[17]

3.1 Federal Procurement in the United States

Federal agencies have historically utilized procurement to invest in innovations aligned with federal priorities by using the purchasing power of the federal government to increase demand. In fiscal year 2022, the federal government obligated $694 billion through contracts for purchasing services and products from both civilian and defense agencies.[18] The Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA) are two agencies that have used procurement to support the rapid commercialization of technologies, resulting in widely used innovations like integrated circuits, computers, jet engines, Earth-orbiting satellites, and solar photovoltaics.[19] This type of procurement of innovation at the DoD is planned to continue, with proposed spending of $276 billion in 2023 on “Acquisition,” which includes Research, Development, Test, and Evaluation (RDT&E), and Procurement, primarily for weapon systems.[20]

Federal procurement has also been used to cost-effectively stimulate clean energy innovation. In the mid-1990s, DOE’s Federal Energy Management Program (FEMP) implemented the Federal Procurement Challenge to enable market entry for advanced energy-saving technologies and products, lower the cost of efficient products by providing a large reliable market, and expand markets for energy-efficient products. The initiative was modeled loosely after DoD and NASA technology procurement programs although, rather than serving as the customer, DOE served as an aggregator of demand across multiple buyers in federal, state, and local governments as well as the private sector.[21]

3.2 U.S. Federal Procurement of Innovation Instruments

Procurement is typically conducted to acquire commercially available products with the sole purpose of obtaining higher quantities of supply. Procurement in the context of innovation is unique because it focuses on stimulating the development of multiple solutions while increasing the supply of a solution, with both phases being necessary for successful innovation. Therefore, the U.S. government procurement of innovation may be organized into three categories: instruments that support the 1) R&D phase, 2) commercialization phase, or 3) both R&D and commercialization phases. Examples of these instruments are highlighted in Table 2 and described below.

Table 2. Examples of Federal Procurement of Innovation by Technology Development Stage.

Technology Development Stage	Instrument	Select Agency Use
Research and Development	Research and Development Contracting (FAR 35)	National Science Foundation US Agency of International Development U.S. Naval Research Laboratory Defense Advanced Research Projects Agency [19,20,21,22]
	Procurement for Experiments (10 USC 2373)	Deparment of Defense
Commercialization	Partnership Intermediary Agreement (PIA) (15 USC 3715)	Department of Energy Department of Homeland Security Advanced Research Projects Agency for Health (ARPA-H)[23,24,25]
	Defense Commercial Solutions Opening (CSO) (Section 879 2017 NDAA)	Department of Defense
Research and Development and Commercialization	Small Business Innovation Research (SBIR)	Department of Agriculture Department of Commerce Department of Defence Department of Energy Department of Education Department of Health and Human Services Department of Homeland Security Department of Transportation Environmental Protection Agency National Aeronautics and Space Administration National Science Foundation[26]
	Small Business Technology Transfer (STTR) Program (15 USC 637c)	Department of Defence Department of Energy Department of Health and Human Services National Aeronautics and Space Administration National Science Foundation[27]
	Other Transaction Authority (OTA) (10 U.S.C 4021)	Department of Defense National Aeronautics and Space Administration Department of Health and Human Services Department of Energy Department of Transportation Federal Aviation Administration Transportation Security Administration[28]

3.2.1 R&D Instruments

R&D Contracting and Procurement of Experiments are procurement instruments that support the R&D phase of innovation.

R&D Contracting (Federal Acquisition Regulation 35)

The purpose of R&D contracts is to advance and apply scientific and technical knowledge to achieve agency and national goals. R&D contracts are unique from contracts for supplies and services because they are directed toward objectives where the work or methods cannot be precisely described in advance, making it difficult to predict the success of R&D contracts. To encourage the best engagement from the scientific and industrial community, the R&D contracting process prioritizes an environment with flexibility and minimum administrative burden.[22] For example, the U.S. National Science Foundation began piloting the use of Broad Agency Announcements (BAAs) (Federal Acquisition Regulation (FAR) 35.016) as an alternative form of funding opportunity to encourage and broaden engagement from new communities of scientists and engineers such as in industry and nonprofits. A BAA is a competitive solicitation method that covers various stages of the R&D process, including 1) the acquisition of basic research and applied research, 2) advanced technology development and advanced component development, and 3) prototypes not related to a specific system or hardware requirement.[23] A BAA is typically open to the public, and proposals are accepted for a specified period of time. Common BAAs include R&D studies, requests to develop prototypes, small business innovation research efforts, science and technology initiatives, and technology maturation. BAAs also reduce the administrative burden on organizations that do not normally seek out federal assistance grants through the use of contracts or other types of funding arrangements.[24]

Nontraditional procurement methods are also utilized by the government to acquire technologies and products. For example:

- The central R&D agency of the DoD, the Defense Advanced Research Projects Agency (DARPA), was established to invest in breakthrough technologies for national security and has publically available contracting opportunities for R&D. The Department of Homeland Security (DHS) and the Office of the Director of National Intelligence (ODNI) offer similar opportunities. [25]

- Government-sponsored challenges are maintained by the General Services Administration (GSA) on Challenge.gov, where federal agencies post challenges and prize competitions. Since 2010, nearly 1,200 challenges have been conducted across 100 federal agencies.[26]

- Venture capital funds established by agencies to collaborate with private capital markets to address investment gaps and develop future capabilities. For example, the Central Intelligence Agency's (CIA) In-Q-Tel was founded in 1999 to anticipate technology questions and needs and achieve solutions to ensure national security.[27] The Department of the Army established the Army Venture Capital Initiative.[28]

Procurement for Experiments (10 USC 2373)

Experimental Purpose (EP) awards are broad, ranging from an award for a radar system to items for the development of an autopilot capability. Between 2004 and 2020, there have been fewer than 50 EP awards, possibly due to the lack of guidance and regulation on the topic.[29] The Procurement for EP statute is not defined by the FAR or any other regulation. EP authorizes the DoD to buy ordnance (military supplies), signal, chemical activity, transportation, energy, medical, space-flight, telecommunications, and aeronautical supplies, including parts and accessories, and designs that are necessary for experimental or test purposes in the development of the best supplied needed for national defense. The purchases can also be made inside or outside of the U.S. and by contract or otherwise. That means EPs are not traditional government contracts, grants, or cooperative agreements and offer a more flexible approach in some circumstances for the DoD to make acquisitions in the listed nine expansive categories to allow for flexibility across innovation types. For instance, the category "signal" may not be explained in the statute to allow the government additional flexibility in its use. [30] In order to use EP authority for awards, the DoD requires 1) a description of the items to be purchased and dollar amount of purchase, 2) a description of the method of test or experimentation, 3) the quantity to be tested, and 4) a definitive statement that the use of the EP authority is determined to be appropriate for the acquisition.

3.2.2 Commercialization Instruments

Partnership Intermediary Agreements and Defense Commercial Solutions Openings are procurement instruments that support the commercialization phase of innovation. Examples of this include the DOE's ENERGYWERX PIA and the NAVY's SCOUT program.

Partnership Intermediary Agreement (15 USC 3715)

A Partnership Intermediary Agreement (PIA) enables long-term partnerships between a federal government laboratory and a non-federal entity, such as a state, local government, or affiliated non-profit. The goal of a PIA is to facilitate technology transfer between the federal labs from non-federal entities. For example, the DOE entered its first PIA, led by the Office of Technology Transitions, in 2023 with ENERGYWERX. ENERGYWERX is a hub dedicated to broadening the DOE's engagement and collaborative efforts with industry, utilities, localities, and others to develop, scale, commercialize, and deploy energy technologies and solutions.[31] The PIA will serve as a platform to broaden DOE's engagement and collaborative activities with innovative organizations and novel solutions and service providers.[32] This partnership was openly competed and awarded through a BAA.[33] PIAs help companies identify federal technologies that can be licensed or commercialized and increase the likelihood of successful cooperative activities between the lab and small businesses.[34]

Defense Commercial Solutions Opening (Section 879 2017 NDAA)

A Commercial Solutions Opening (CSO) is a competitive acquisition method that funds innovative commercial products and services that directly fulfill requirements, close capability gaps, or provide potential technological advances through a competitive selection of proposals following a general solicitation and peer review of proposals.[35] An example of this is the Office of Naval Research (ONR)-sponsored SCOUT program, an ongoing, multi-agency campaign that collaborates with industry to accelerate solutions to warfighter challenges.[36] The defense CSO is designed to lower barriers to entry and attract a wide range of companies that may not be familiar with standard federal government procurement processes.[37] Benefits of the CSO strategy include a streamlined application process requiring minimal corporate and technical information, direct feedback to product development teams, and fast-tracked evaluation timelines.

3.2.3 Both R&D and Commercialization Instruments

Small Business Innovation Research (SBIR), Small Business Technology Transfer (STTR) programs, and Other Transaction (OT) Authorities are procurement instruments that support the R&D phase of innovation.

Small Business Innovation Research and Small Business Technology Transfer Programs (15 USC 637c)

The SBIR and STTR programs are highly competitive awards-based programs that encourage domestic small businesses to engage in federal R&D with the potential for commercialization. An example of this is the SBIR/STTR Oil and Gas Program's Natural Gas Infrastructure (NGI) R&D Technology Area, which supports research to advance the resiliency and flexibility of the U.S. natural gas transportation and storage infrastructure.[38] These programs support scientific excellence and technological innovation through federal investments in research to build a strong national economy.[39] In addition to those activities, STTR programs aim to foster technology transfer through cooperative R&D between small businesses and research institutions. Federal agencies with extramural R&D budgets exceeding $100 million are required to allocate 3.2% of the extramural R&D budget to fund an SBIR program, and federal agencies with extramural R&D budgets that exceed $1 billion are required to reserve 0.45% of the extramural R&D budget for the STTR program. Currently, 11 federal agencies participate in the SBIR program, and five of those agencies also participate in the STTR program.

Other Transaction Authority (10 U.S.C. 4021)

Other Transaction (OT) Authorities are procurement authorities used by NASA, DoD, Department of Transportation (DOT), Federal Aviation Administration (FAA), Transportation Security Administration (TSA), Department of Health and Human Services (HHS), and DOE to enter into agreements with non-traditional contractors.[40] OTs have been used by NASA for the past 60 years since its creation by President Eisenhower in 1958.[41] These can be used to carry out certain prototypes, research, and production projects flexibly and allow agencies to incorporate business practices that reflect commercial industry standards and best practices. An example of OT authority use was the development of the Mine-Resistant Ambush Protected (MRAP) vehicle, further discussed in the next section. OTs can bypass certain Federal Acquisition Regulation requirements to speed up the acquisition process and make it more flexible. Agreements are typically used for innovative, medium to high-risk, and often short-timeline projects.

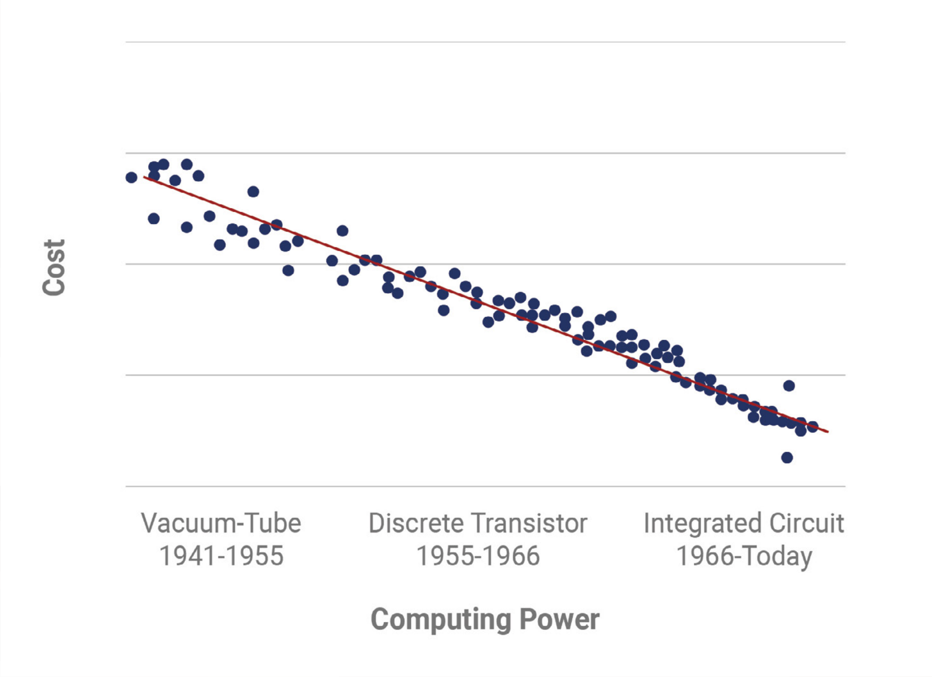
3.3 Successful U.S. Government Procurement Programs

There is a long history of the federal government committing to initial procurement contracts that have led to the development of new industries. These new industries have been developed as a direct result of meeting federal government needs, which is analogous to the situation we see today with the development of a CDR market.

Project Apollo — NASA's Project Apollo was initiated in 1961 to land Americans on the moon and then return them safely to Earth. The government established this goal to win the Space Race against the Soviet Union to ensure national security and demonstrate U.S. preeminence in space innovation. This program awarded the Massachusetts Institute of Technology (MIT) the first contract to develop the Apollo Guidance Computer (AGC) for the mission. MIT required improvements to a new, risky, and undeveloped technology: integrated circuits, or microchips, to design a compact yet powerful computer.[42] MIT collaborated with early chip companies like Fairchild Semiconductor, Texas Instruments, and Philco to improve the manufacturing quality of the microchips, and through NASA, procured hundreds of thousands of microchips.[43] In 1962, the U.S. government purchased 100% of microchips at the initial cost of $1,000 each, with NASA as the primary user of the chips. Increased demand drove down the cost to $15 per microchip by 1963, and by 1969, the cost of each integrated circuit was $1.58, with significantly more capability and reliability. Additionally, supply also increased; in 1965, the volume of chips produced was 20 times that of 1962. As a result of the U.S. government's initial procurement of microchips, the semiconductor industry, for the past 50 years, has produced a 30% reduction in costs per year while doubling the computing power per chip about every two years, as seen in Figure 2.[44] Today, the microchip market is worth billions of dollars worldwide and is critical in thousands of products like TVs, radios, car electronics, computers, and mobile phones.

Commercial Orbital Transportation Services — From 2006 to 2013, NASA's Commercial Orbital Transportation Services (COTS) program allowed NASA to act as an investor and advisor, collaborating with distinct companies in the space transportation industry to promote the development of U.S. spact transportation. COTS also supported President George W. Bush's 2004 Vision for Space Exploration by creating new commercial vehicles that would transport cargo to and from low-Earth orbit, so that NASA spacecrafts could stay in space longer.[45] The COTS program stimulated the private sector to develop and operate safe, reliable, and cost-effective commercial space transportation systems. It resulted in the SpaceX Dragon, the first commercial spacecraft to deliver cargo to the International Space Station (ISS), and Orbital Sciences Corporation's resupply mission to the ISS.

Figure 2. Microchips: Steady March to Lower Costs and More Powerful Computing.



Source: Scientific American

Mine-Resistant Ambush Protected Program — In the early years of the Iraq and Afghanistan campaigns, 75% of U.S. soldier casualties were attributed to improvised explosive devices (IEDs). In February 2007, the DoD initiated the Mine-Resistant Ambush Protected (MRAP) program, which used an OT authority to rapidly acquire and field vehicles that could mitigate the threat of EIDs. This OT authority condensed the R&D and production of MRAP vehicles to just 90 days, compared to the typical 18- 24 months of the traditional FAR/Defense FAR Supplement (DFARS) acquisition life cycle, and resulted in saving thousands of U.S. soldiers' lives.[47] In May 2007, the Secretary of Defense affirmed MRAP as DoD's most important acquisition program.

High Altitude Endurance Unmanned Aerial Vehicle Program — The High Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) program began in June 1994 by the DoD's Defence Advanced Research Projects Agency to address problems of past UAV development efforts. This new procurement program had several key elements: 1) categorized as an Advanced Concept Technology Demonstration (ACTD) to demonstrate military utility in a short time frame, 2) use of OT authority, resulting in a tailored program structure with increased flexibility and lower overhead costs, and 3) a firm cost requirement of $10 million for air vehicles.[48] DARPA procurement of UAV systems has been transformative to warfighting and intelligence, surveillance, and reconnaissance capabilities.49

Antiepileptic Drug Development Program — The Antiepileptic Drug Development (ADD) program was created in 1975 to encourage the development of medications to treat epilepsy, which afflicts 2 million Americans. This program is situated within the Epilepsy Branch of the National Institute of Neurological Disorders and Stroke (NINDS) and has a budget of $4 million used for extramural contracts. The program was created because the existing drugs to treat epilepsy still resulted in 10% of patients experiencing seizures, and many patients experienced side effects. The program was designed to stimulate the private sector by providing incentives to develop and market a new generation of antiepilepsy drugs by sharing funding and offering expertise with controlled clinical trials and preclinical screenings. Over the course of 20 years, the program, in conjunction with drug companies, successfully brought six effective drugs to market. The program is currently focused on medications to deter epilepsy symptoms.[50]

4. Bridging the Gap to CDR Commercialization: Procurement

U.S. federal procurement has successfully supported innovative RD&D to achieve rapid commercialization during crucial moments in U.S. history, as seen in Section 2 with the development of microchips and defense vessels. Project Apollo demonstrated that procurement can help drive down cost quickly while catalyzing scale. The Antiepileptic Drug Development program showed that an advanced market commitment structure that outlines an initial budget fosters competition for a diverse set of solutions to mature. Procurement of innovation helps bridge the "valley of death," the large gap between early-stage scientific research and industry commercialization, by maintaining the crucial stage of translational research and progress, which is often underfunded.[51] Therefore, the utilization of a competitive procurement model, or the reverse auction model, can be used to drive innovation, create jobs, develop the CDR industry, and improve the existing voluntary carbon market. A reverse auction with an innovation procurement focus allowing multiple CDR solutions to compete and come down in cost within a technology type would rapidly bridge the gap between early-stage scientific discovery and the commercialization of quality CDR innovations.

4.1 Reverse Auction: An Optimal CDR Procurement Solution

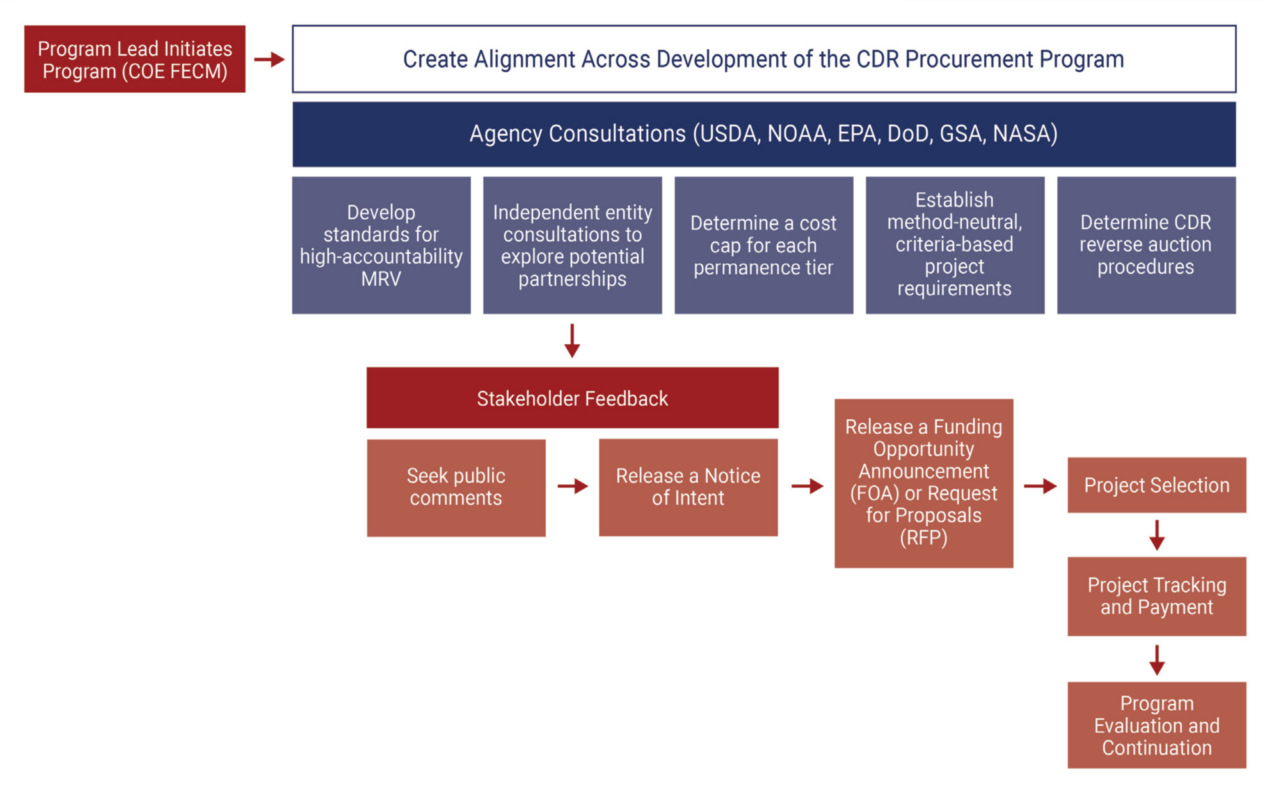
To efficiently and effectively accelerate the deployment of CDR, the concept of a reverse auction emerges as a highly promising and optimal solution. Unlike traditional procurement methods, which often entail a fixed price set by the buyer, reverse auctions flip the dynamics, inviting suppliers to compete in offering the lowest cost or most favorable terms. In the case of innovation procurement, there needs to be set criteria to define a productive CDR profile before a program can be established. Recommendations for considerations for developing a federal CDR procurement reverse auction program with these productive criteria can be found in Section 3.2. For CDR, where innovation, cost-effectiveness, and scalability are paramount, the application of reverse auctions not only aligns with these objectives but also holds the potential to unlock a new era of CDR technology acquisition. Reverse auctions incentivize:

- **Competition and Innovation:** Reverse auctions stimulate competition among suppliers, encouraging continuous innovation in CDR technologies. The competitive nature of reverse auctions allows the government to identify qualified suppliers in a technologically neutral manner and select the most innovative and efficient solutions to stimulate competition within a dedicated CDR pathway. For example, direct air capture technologies would compete against other direct air capture competitors. Competition within CDR pathways allows diverse innovation while promoting competition without inadvertently excluding solutions with high carbon removal potential and the capability to come down in cost over time.
- **Cost Reduction:** Reverse auctions promote cost efficiency by encouraging competition among sellers, leading to potential savings for the government. Suppliers will compete to provide CDR technologies at the lowest price, allowing the government to select the most economically advantageous offer. This mechanism incentivizes suppliers to optimize their costs, potentially accelerating cost reductions of procurement while ensuring that all their requirements are met.[52]

4.2 Considerations for Developing a Federal CDR Procurement Reverse Auction Program

In developing a successful federal CDR procurement program, many aspects throughout the establishment process will need to be thoughtfully considered and evaluated with feedback from key stakeholders. Possible priorities for a successful Federal CDR procurement program are roadmapped below and in Figure 3.

Figure 3. Considerations and Processes for Federal CDR Procurement Reverse Auction Program Development.



1. **Program lead**– DOE-FECM is an ideal lead for a CDR procurement program because of existing internal expertise on existing and potential CDR technologies and approaches. FECM may partner with the Office of Clean Energy Demonstrations (OCED), which supports the deployment of CDR technologies through programs like the Regional Direct Air Capture Hubs.
2. **Agency consultations**– DOE-FECM should consult with federal agencies experienced in the government procurement process for products and services such as DoD, GSA, and NASA, and agengies with substantive CDR expertise such as USDA, NOAA, and EPA. The consultations will allow the DOE to build in-house expertise with existing procurement processes and tools utilized by the federal government, such as contracting mechanisms and methods to reduce extraneous fees. Federal agencies to consult with include the GSA, the DoD, the Department of State, and the Department of the Interior.[53]
3. **Develop standards to ensure high-accountability MRV** – Robust MRV holds suppliers of CDR accountable to purchasers and ensures accurate accounting to reach global climate goals. Currently, most MRV protocols have been developed through the voluntary market, and some CDR companies have developed MRV guidances for their unique technologies. To ensure federal CDR procurement is successful, DOE-FECM should develop guidelines or standards that MRV methodologies need to meet for the various CDR pathways. DOE-FECM can consult with other federal agencies, academic institutions, national labs, non-profits, and the private sector to increase expertise on the MRV needs of different CDR pathways.

4. **Independent entity consultations**– DOE-FECM should consult with independent CDR procurement entities, sometimes referred to as third-party consultants, to understand the dynamics of potential partnerships. A partnership may be beneficial in alleviating resource constraints and providing time for the DOE to gain further CDR procurement expertise and develop an in-house procurement program. A partnership arrangement may consist of non-monetary support measures, like help with siting and permitting and transparent project vetting. It would be in DOE-FECM's best interest to maintain control of purchasing agreements to avoid possible future legality considerations with misuse of funds and the lack of ability to justify purchases if all technology evaluation and purchasing is done externally, particularly if there is a lack of visibility into the independent entity's activities.
5. **Determine a cost cap** – The current average market price per net ton carbon dioxide equivalent basis will need to be determined for each permanence tier. This market price can be set as the maximum price per ton to be paid under the reverse auction within each permanence tier and technology type and revised yearly as costs come down over time.
6. **Establish method-neutral, criteria-based project requirements** – DOE-FECM should create requirements that carbon dioxide removed from the atmosphere must meet to be eligible for the procurement program. Requirements may include additionality, a set delivery date after the date of purchase, an MRV plan approved by the DOE, and permanence levels through storage or usage. Permanence levels may include a medium tier for bids with a permanence between 100 and 1000 years and a long-term tier for bids with a permanence of 1000 years or more. Technology diversity should also be considered as a project requirement to support a portfolio of CDR solutions and ensure fair competition within the same CDR process. Competing within the same technology type is necessary as newer, undiscovered, CDR approaches may have different cost profiles compared to pre-existing CDR solutions.
7. **Determine CDR reverse auction procedures** – DOE-FECM must create a detailed and transparent procedure of how it will solicit bids from eligible entities, maintain confidentiality among bids, award bids, evaluate project success, and provide payments. This is necessary to provide clear guidance for eligible entities planning to participate in the CDR procurement program and be utilized by the DOE-FECM to navigate the program. The procedure may describe the necessary components of a successful bid, including:
    - A desired price for each ton of carbon dioxide equivalent removed from the atmosphere;
    - Annual net ton carbon dioxide equivalent removed to be purchased at the desired price;
    - Details of the durability or permanence of removed carbon dioxide;
    - Details on the techno-economic analysis or required level of engineering and associated cost to inform the all-in costs; and
    - A life cycle assessment to quantify carbon dioxide removed.
8. **Seek public comments** – Once MRV standards, permanence tiers, cost cap, project requirements, and the reverse auction specifications are determined, the DOE-FECM should publicly publish a draft strategic framework of the CDR procurement program and seek public comments from stakeholders such as federal agencies, industry, academia, non-profits, and individuals through a Request for Information (RFI). This will ensure the program addresses stakeholder input and further enhances DOE-FECM's understanding of CDR procurement. To engage an optimal number of stakeholders, robust circulation of the RFI is necessary across appropriate channels, such as DOE press releases and announcements from the DOE Secretary.

9. **Release a Notice of Intent (NOI)** – After public comments from an RFI have been considered and necessary revisions have been made, the DOE-FECM should announce its intent to initiate the CDR procurement program alongside a finalized CDR procurement program strategic framework.
10. **Release a Funding Opportunity Announcement (FOA) or Request for Proposals (RFP)** – The DOE-FECM should release a FOA or RFP to solicit bids from eligible entities for the CDR procurement program, with a reasonable deadline and expected dates for eligible entities to be notified throughout the selection process.
11. **Project Selection** – After the FOA submission deadline for bids, the DOE-FECM will select projects for the CDR procurement process based on the previously determined and extensively reviewed selection criteria.
12. **Project Tracking and Payment**– After selected projects are notified and announced, the DOE-FECM will track project progress to ensure timely delivery of CDR removal and provide payments based on agreed-upon terms.
13. **Program Evaluation and Continuation**– Evaluation of each step of the CDR procurement program should occur and be recorded throughout the life of the program, to ensure the program is progressing effectively and to identify how to update the program in future iterations.

5. Emerging Carbon Market Dynamics and Regulatory Frameworks Coincide with the Growing Interest in CDR

CDR demand in the U.S. has been mainly supported by the voluntary corporate purchases, where entities who have made voluntary emissions reduction commitments purchase carbon credits to offset difficult-to-abate emissions. The private sector and philanthropic support for carbon removal have historically engaged in the voluntary carbon market through nature-based pathways for carbon removal, such as afforestation and reforestation. As the CDR space develops with the entrance of new engineered and hybrid CDR technologies, the voluntary carbon market will also need to expand and evolve to accommodate the growing market and address customer priorities regarding transparency, quality, and standardization.

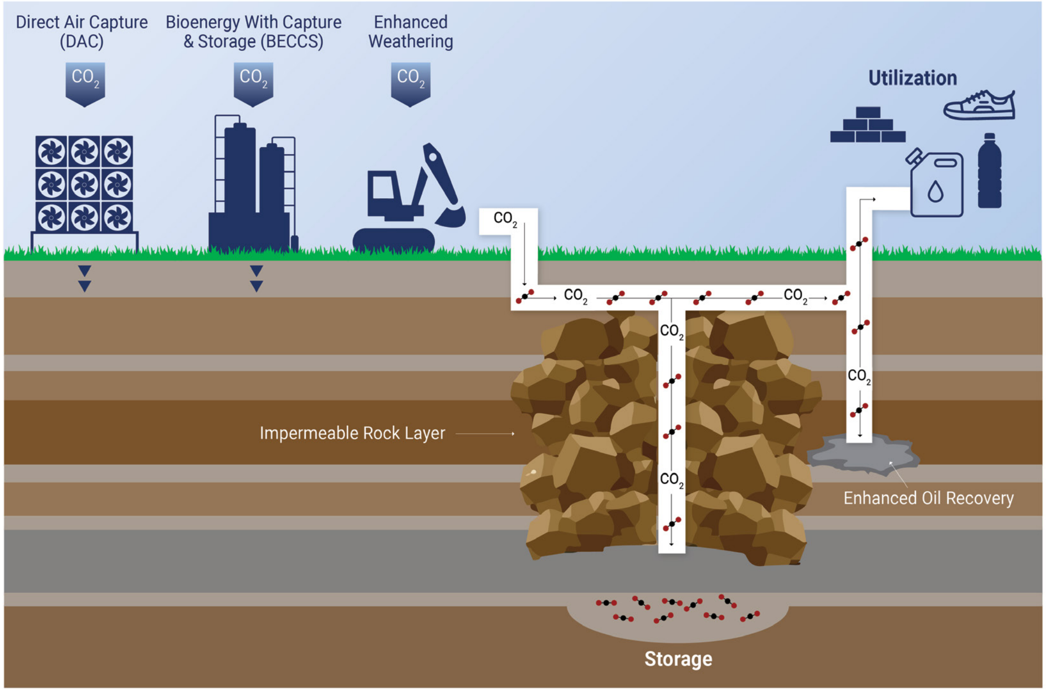
CDR's critical role in achieving net-zero decarbonization drives individual consumers and governments to support the CDR industry. For instance, the U.S. government recently made first-of-its-kind investments in carbon management RD&D and is encouraging the commercialization of CDR technologies through tax incentives and pilot procurement programs. Individual consumers are also beginning to comprehend the value of CDR and how it will impact their future purchasing behavior. For instance, the demand for products with a "carbon neutral footprint" or sustainability label will increase as younger people, who often voice a preference for these products, gain purchasing power.[54]

To meet the projected growing demand for CDR, additional support to expand the CDR market is needed to ensure promising CDR technologies can contribute to global emissions reductions. A robust, competitive U.S. federal procurement program is a mechanism that can drive guaranteed and long-term demand for CDR solutions to make that market grow.

5.1 Economics Across the CDR Value Chain

Purchasing CDR is not the same as purchasing carbon dioxide or a "carbon price." CDR is a service, meaning the cost includes building and operating facilities and capturing, storing, transporting, and utilizing or sequestering carbon dioxide. These costs are then divided by the metric tons of carbon dioxide that end up getting removed, outlined in Figure 4. This CDR "service" often comes as a full package because CDR has many associated costs if CDR providers want to provide value that is truly additional, durable, measurable, quality solutions that can be verified over the committed time horizons.

Figure 4. Carbon Dioxide Removal Value Chain and Cost Profile for DAC, BECCS, and Enhanced Weathering.

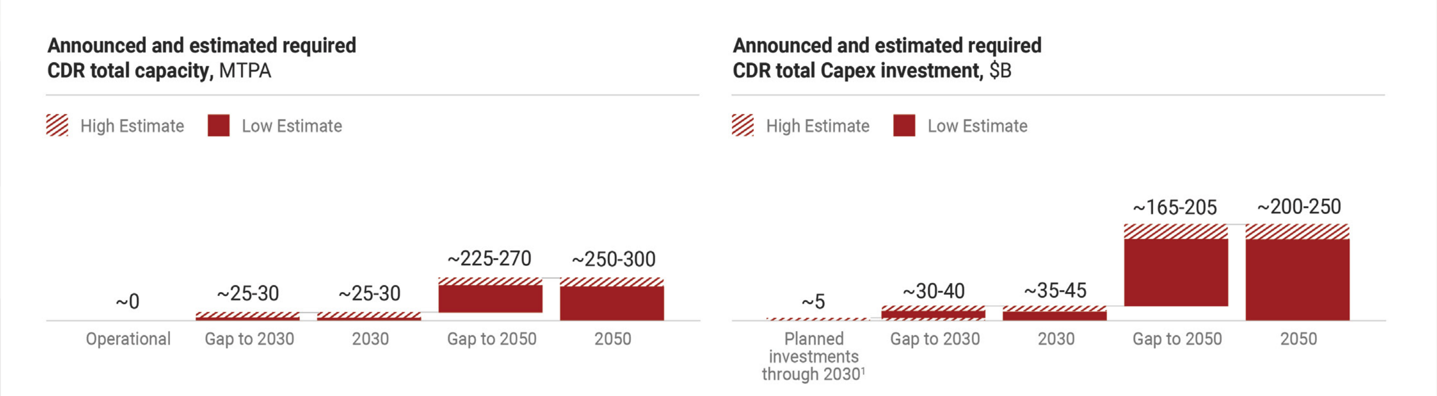


The goal that many organizations set to reach net zero requires the accounting of organizational emissions to determine the amount of CDR needed to balance residual emissions to meet that goal. Organizational emissions are then amounted to a total amount of carbon dioxide or carbon dioxide equivalents. CDR providers then sell their service per metric ton of carbon dioxide removed and securely sequestered. As such, many organizations buying CDR pay for the full service of CDR, where the cost is calculated against the metric tons of carbon dioxide removed from the atmosphere, less the associated emissions with removing them (i.e. net metric tons removed). An additional denominator that is not typically factored in is the temporality of the sequestration. For example, an offset for sequestration that may only last 5 years and cost $5 has a cost of $1/year. A $300 per ton CDR that has sequestration for 1,000 years has a cost of $0.30/year of sequestration. Because you are buying a full service and not simply paying for offsets, CDR is not equivalent to a price on carbon. As a result of these net-zero goals, a shortage of quality removals has surfaced. A Rhodium study found that 689 to 2,260 million metric tons of DAC alone is necessary to achieve net-zero emissions by 2050, equivalent to the emissions of 150 to 490 million passenger vehicles per year.[55] Though solutions like DAC and BECCS are considered more mature and quality CDR approaches, there are many other emerging CDR solutions that can continue to grow the industry and create significant employment and business opportunities across its supply chain.

5.2 Existing U.S. Federal and Private Sector Tools for CDR Deployment

Carbon removal technologies with high durability or permanence and more established yet nascent MRV methods are still in the early stages of demonstration. As of 2022, engineered CDR has seen limited commercial deployment, with approximately 40 pilot-scale projects that are estimated to achieve 100,000 metric tons per year of global capacity. America is leading the way, as many of these planned projects are DAC demonstrations prompted by bipartisan Infrastructure Investment and Jobs Act (IIJA) funding, tax incentives, and private sector purchasers willing to initially pay high prices as part of their decarbonization strategies.[56] Additional federal and private support mechanisms will be needed to accelerate the research, development, and deployment of the next generation of CDR technologies and to meet estimated CDR total capacities and support net-zero commitments.

Figure 5. Total CDR Capacity and Investments



Source: U.S. DOE

5.2.1 Current Federal Support Mechanisms for CDR

As shown in Section 2, the federal government's buying power has historically been leveraged to support high-risk technologies ranging from efforts in research and development, demonstration and deployment, and commercialization. Successfully implemented federal support mechanisms can enhance investments in CDR innovations and employment opportunities across the varied stages of development and commercialization. This method was essential for scaling fracturing technologies by driving down costs.[57] The optimal federal support mechanism would consider the various factors differentiating CDR innovations, such as business models, stage of maturity, and cost.

CDR Purchase Pilot Prize

A new DOE FECM program that was officially launched on September 29, 2023, called the CDR Purchase Pilot Prize, provides $35 million in awards to private entities and academic institutions over three phases to compete for the opportunity to sell CDR credits directly to DOE. The three phases will include CDR credit concept proposal, sample purchase contracts, and finalist awards for CDR successfully delivered and verified. This program is the early stage of a much more robust program and acts as the perfect opportunity to implement many of this report’s structural considerations. This program will help build metrics for successful CDR programs and create a market to encourage technology innovation and the growth of the industry.

The CDR Purchase Pilot Prizeis a vital federal program that can lay the groundwork for the broader recommendation this report covers. This program would allow DOE FECM to develop an initial understanding of the CDR supply landscape and begin to develop technical knowledge on how to purchase CDR effectively. A larger reverse auction CDR innovation procurement program, like the one outlined in this report, would allow DOE FECM to harness the experience gained from the CDR Purchase Pilot Prize, scale up its efforts significantly, and enable DOE FECM to procure a substantial volume of highly diverse CDR solutions.

Furthermore, the success of the CDR Purchase Pilot Prize will serve as a beacon for private entities and academic institutions to invest in research and development of CDR technologies, as they see a clear path to monetize their innovations. The emergence of a competitive market for CDR will incentivize the development of more efficient and cost-effective carbon removal solutions.

Tax Law

Section 45Q of the United States Internal Revenue Code was first introduced in 2008 and provides a tax credit to incentivize the deployment of carbon capture, utilization, and storage. In 2022, 45Q was expanded to include the tax credit for DAC to $180 per ton of carbon dioxide permanently stored and $130 per ton for used enhanced oil recovery. The 45Q changes also reduced capacity requirements for eligible projects, with DAC facilities at 1,000 metric tons per year, and included a seven-year extension to qualify for the tax credit, so projects have until January 2033 to begin construction.[58] These changes reflect DAC’s higher capture costs and have right-sized the credit to match the industry's existing scale and technical maturity.

The Infrastructure Investment and Jobs Act

The bipartisan IIJA, enacted in November 2021, included over $12 billion in investments for carbon management. This highlights the federal government's commitment to utilizing CDR to achieve net-zero commitments by improving efficiencies and costs of new engineered technologies like DAC and further driving down costs through supporting commercialization.[59] These investments include approximately $6.5 billion in new carbon management funding over fiscal years 2022-2024, largely for DAC and carbon dioxide storage.[60] The IIJA also included $2.7 billion for land management that could protect and increase carbon sequestration on natural and working lands. DAC-specific support through the IIJA is outlined in Table 3.

Table 3. IIJA DAC Support

Program	Agency	Investment	Description
DAC Hubs	DOE Office of Clean Energy Demonstrations (OCED)	$3.5 Billion	Develop four regional DAC Hubs, each with capacity to capture, store, and/or utilize 1 MMT of carbon dioxide annually.
DAC Prizes	DOE Office of Fossil Energy and Carbon Management (FECM)	$115 Million	Advance CDR technologies and the incubators accelerating them. $15 million for the DAC Pre-Commerical Prize. $100 million for commercial projects through the DAC EPIC Prize. [85]
Advancing CDR measurement, reporting, and verification	DOE Office of Technology Transitions (OTT) and FECM	$15 Million	Accelerate the commercialization of CDR technologies, including DAC, by advancing measurement, reporting, and verification best practices and capabilities.[86]

*The first $1.2 billion to advance the development was announced in August 2023 for two commercial-scale DAC facilities in Texas and Louisiana.[61] An additional 19 projects were announced to support earlier stages of project development, including 14 feasibility assessments and 5 front-end engineering design studies.[62]

DOE Carbon Negative Shot

The DOE Energy Earthshot Initiative was established in 2021 with the purpose of driving collaborative development across DOE's R&D community to accelerate innovations that reduce and remove emissions to achieve net-zero goals, reduce technological costs, and enhance U.S. competitiveness. The third Energy Earthshot – Carbon Negative Shot – was announced in November 2021. It called for the development of technologies and approaches that will remove carbon dioxide from the atmosphere and durably store it at gigaton scales for less than $100 per net metric ton of carbon dioxide equivalents.[63] This was the U.S. government's first major effort in CDR. In August 2023, after receiving bipartisan direction from Congress, the Carbon Negative Shot Notice of Intent (DE-FOA-0003081) was issued and included the following funding opportunities.

- $35 million for the CDR Purchase Pilot to fund purchase agreements over several prize phases between CDR suppliers, representing diverse technologies, and the DOE. This is the world's first direct government CDR purchasing effort.

- $60 million for the DAC Pilot Prize to support the next generation of transformational DAC technology at approximately 1-5 ktCO2/year scale.
- Small CDR Pilots to include Biomass Carbon Removal with Storage (BiCRS), enhanced mineralization, multi-pathway CDR test beds, and marine CDR.
- MRV funding to support robust carbon crediting.

FY2023 Appropriations Act

The FY2023 Energy and Water Development Appropriations Act provided $140 million for coordinated research, development, and demonstration of CDR technologies across the Office of Energy Efficiency and Renewable Energy (EERE), FECM, and Office of Science, as authorized in section 5001 of the Energy Act of 2020.[64] Additionally, the DOE was also directed to establish a competitive purchasing pilot program for the purchase of carbon dioxide removed from the atmosphere, as authorized in section 969D of the Energy Policy Act of 2005.

5.2.2 Private Sector Support Mechanisms for CDR

In addition to recent increases in federal support for CDR, philanthropic funding for carbon removal has increased from $80 million per year in 2018 to $175 million in 2023.[65] Nearly three-quarters of philanthropic support for CDR went to natural solutions, which are estimated to be capable of providing 37% of cost-effective carbon dioxide mitigation needed through 2030 to reach the climate goals.[66] However, investments in engineered (i.e., DAC), hybrid (i.e., enhanced weathering), and ocean CDR solutions are necessary to deploy various CDR solutions at scale and bring down costs. A snap-shot of private-sector CDR purchasing agreements in 2023 that equal approximately 1.2 million metric tons of carbon dioxide is below include:

- JPMorgan Chase signed long-term agreements to purchase more than $200 million of CDR intended to remove and store 800,000 metric tons of carbon dioxide from the atmosphere. The agreements include a 9-year contract with Climeworks to deliver 25,000 metric tons of carbon dioxide via DAC and a 5-year deal with Charm Industrial to store 28,500 metric tons of carbon dioxide through bio-oil production and storage.[67]
- Frontier signed a $53 million multi-year contract with Charm Industrial to remove 112,000 metric tons of carbon dioxide between 2024 and 2030. [68]
- NextGen CDR Facility (NextGen), a joint venture South Pole and Mitsubishi Corporation, announced the advance purchase of over 193,000 metric tons of CDR, which will include CDR from the DAC project developed by 1PointFive in Texas and Summit Carbon Solutions in the U.S. Midwest.[69]
- Microsoft announced an agreement with RunningTide, an ocean CDR start-up that removes carbon by permanently sinking seaweed to the deep ocean, to remove 12,000 metric tons of carbon dioxide.[70]
- Boeing signed a pre-purchase agreement over a five-year period with Equatic, an ocean CDR start-up that removes carbon dioxide from seawater and produces hydrogen, to remove 62,000 metric tons of carbon dioxide and deliver 2,100 metric tons of carbon-negative hydrogen to Boeing.[71]

These recent increases in public and private sector investments represent promising market opportunities for CDR. However, to achieve net-zero commitments, continued momentum will be essential. Therefore, a robust, competitive U.S. federal procurement mechanism, which drives guaranteed secure and long-term demand for CDR solutions, is a promising method to effectively scale the CDR market, induce private investment, and minimize costs.

6. Conclusion

CDR solutions represent a pivotal and promising avenue for addressing the existing and increasing levels of carbon dioxide in the atmosphere. As utilities and the private sector work towards meeting decarbonization targets, it is evident that CDR offers a diverse array of approaches to capture and sequester carbon at the gigaton scale, playing a vital role in achieving net-zero emissions by 2050.

While private sector investments in CDR are on the rise, the current landscape is marred by unverified and low-quality carbon removals, leaving much room for improvement. Government support through competitive federal procurement programs can be a game-changer in accelerating the deployment and commercialization of the CDR industry, create jobs, and catalyze private sector investment. Such programs have a track record of catalyzing innovation, as seen with semiconductors, space flight, energy storage, and vaccines, and they can do the same for CDR solutions.

The federal government can act as an enabling force, ensuring that CDR technologies become accessible, affordable, and readily available in the market. Moreover, by harnessing the power of competition, a competitive federal procurement program can not only expedite innovation and efficiency but also guarantee a supply of quality CDR solutions.

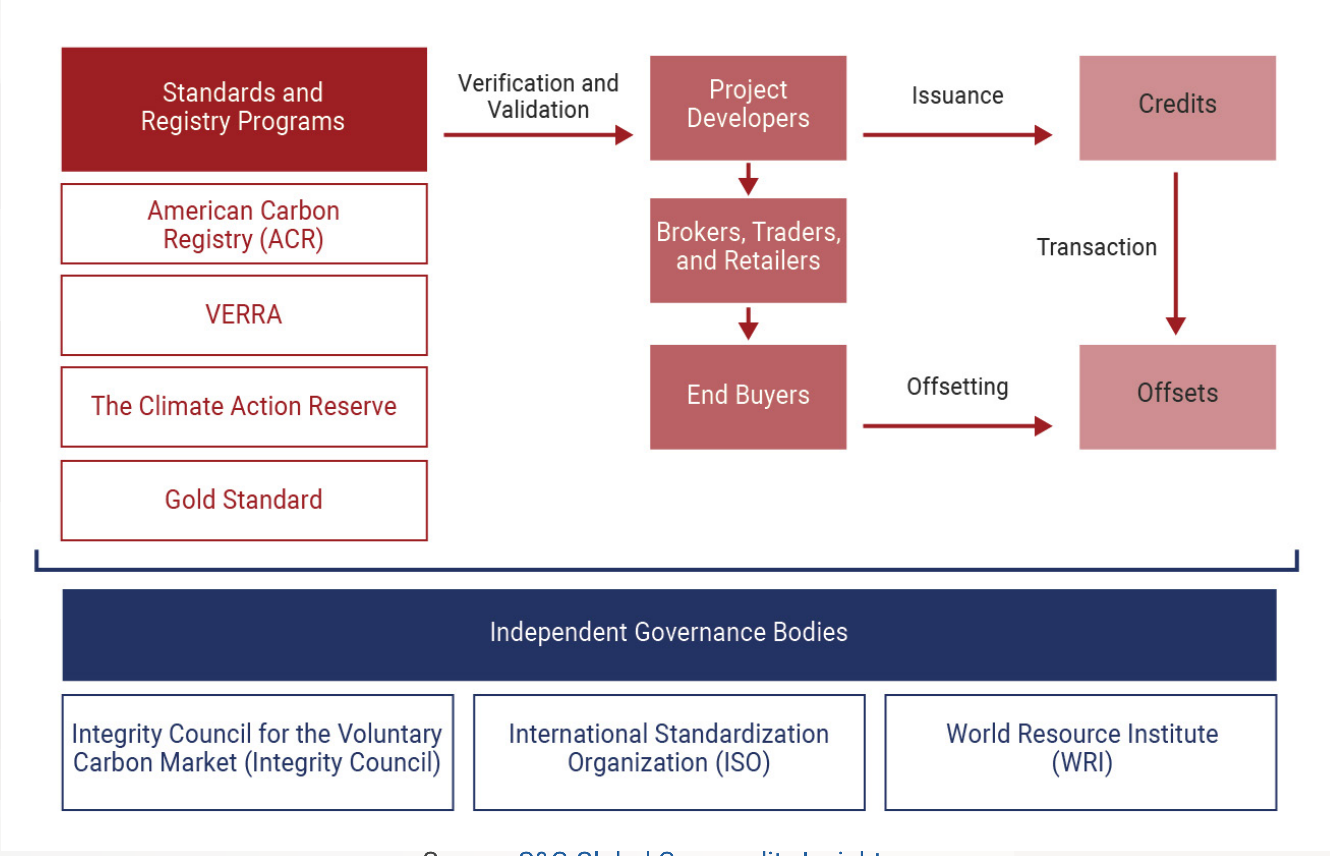
Appendix

Global and Domestic Carbon Market Dynamics and Regulatory Frameworks

The U.S. carbon market is primarily voluntary, compared to the EU and UK, which rely on mandatory carbon markets to cover specific industry sectors and emissions. Unique cases within the U.S. include some states with implemented mandatory carbon markets known as the Cap-and-Trade Program. Similarly, the Regional Greenhouse Gas Initiative (RGGI) is an agreement among 12 states to cap emissions from power plants.[72]

Voluntary carbon markets allow companies, who choose to do so, to offset their emissions by purchasing carbon credits. Each credit, equivalent to one metric ton of reduced, avoided, or removed carbon dioxide or equivalent greenhouse gas, can be used by a company to “offset” one ton of carbon dioxide or equivalent gasses they emit.[73] Once it’s purchased, it is moved to a register for retired credits or retirements, and it is no longer tradable.

Appendix Figure 1. Diagram of the U.S Voluntary Carbon Market



Source: S&G Global Commodity Insights

Many standards and registry programs are associated with voluntary carbon markets. Some noteworthy examples include the American Carbon Registry (ACR), Verra, the Climate Action Reserve (CAR), and the Gold Standard. While it is good that there are a number of programs that exist, the various registries use different methodologies to calculate what makes a "quality" carbon credit. Additionally, due to the significant variance in carbon certifications, the supply of carbon credits has mainly consisted of land-based solutions such as afforestation, reforestation, and ambiguous pathways like avoided conversion, which preserves forests but does not directly remove carbon dioxide from the atmosphere.[74] However, when standards subscribe to specific rules, principles, and guidance, the common concerns of transparency, reporting, additionality, and quality verification are eased. When these standards are in place, revising certification rubrics to include new carbon removal technologies and solutions, like DAC, becomes more streamlined.

Therefore, certification bodies such as the Integrity Council for the Voluntary Carbon Market (Integrity Council), the International Standardization Organization (ISO), and the World Resource Institute (WRI) offer varied guidances to mitigate the lack of transparency and quality concerns and ensure that buyers receive credits with a reliable price and quality.

Voluntary Carbon Market Certification Bodies Criteria

The Integrity Council for the Voluntary Carbon Market

The Integrity Council created criteria for high-integrity carbon credits through its Core Carbon Principles. Many parties in the carbon credit landscape, from project developers to valuation standards bodies, subscribe to the Core Carbon Principles. The principles were constructed using feedback from over 350 submissions from key stakeholders regarding assessments of the carbon-crediting process.[75] The principles follow the themes of governance, emissions impact, and continuous development.[76]

- Governance principles address the clarity of carbon credit systems. The presence of different standards poses a challenge of complexity in tracking, reporting, and verifying decarbonization efforts. Without secure governance, accountability measures are vulnerable, leading to consumer uncertainty over price and quality.
- Additionality and permanence are paramount criteria in distributing credits, meaning that credits must only be distributed for activities that alter business as usual toward a future of reduced carbon. Furthermore, calculation approaches must be clear, measurable, and avoid double-counting. [77]
- Development principles contribute to the overarching goal of fostering a system of mitigation activities that deliver consistently positive results towards achieving net-zero commitments by mid-century. [78]

Many parties in the carbon credit landscape, from project developers to valuation standards, subscribe to the Core Carbon Principles. The principles were constructed using feedback from over 350 submissions from key stakeholders regarding assessments of the carbon-crediting process.[79]

The International Organization for Standardization

The International Organization for Standardization (ISO) offers similar accreditation promoting compliance standards that enhance environmental quality. ISO's standards 14064 and 14065 are widely used to quantify, report, and verify GHG emissions. These standards work in conjunction with GHG reporting, removal, and verification processes. The guidance they provide is pertinent to carbon credit markets.

- ISO 14064-1 specifies how organizations should calculate and report their emissions and removals.
- ISO 14064-2 connects the standard to carbon markets by offering guidance for project quantification, monitoring, and reporting emission reductions or removals.
- ISO 14064-3 describes the verification and validation steps of GHG statements.
- ISO 14065 lays out requirements for entities that undertake the validation and verification process for environmental information. Overall, the ISO 14064 and 14065 standards work in conjunction to guide the GHG reporting, removal, and verification process. Such guidance is pertinent to carbon credit markets.

The World Resources Institute

In 2001, the World Resources Institute (WRI) created the Greenhouse Gas Protocol (GHG Protocol) to address the need for accounting and reporting companies' emissions.[80] The GHG Protocol is similar to ISO 14064 standards in purpose and their widespread usage. However, while the ISO standard broadly establishes basic compliance, the GHG protocol offers recommended steps for companies to optimize for environmental quality.

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