HEARING BEFORE THE SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

Testimony of

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July 27, 2022

Chairman Carper, Ranking Member Capito, honorable members of the committee: Thank you for the opportunity to speak with you today about the critical importance of carbon capture, utilization, and sequestration (CCUS) and carbon dioxide removal technologies. My name is Brad Townsend, and I'm the vice president for policy and outreach at the Center for Climate and Energy Solutions, or C2ES. We are a nonpartisan, nonprofit think tank based in Arlington, Virginia, whose mission is to secure a safe and stable climate, by accelerating the global transition to net-zero greenhouse gas emissions and a thriving, just, and resilient economy.

C2ES works with companies and policy makers to inform and educate business leaders, strengthen corporate action, and mobilize business support for effective climate policy. Our Business Environmental Leadership Council, a group of 41 primarily Fortune 500 companies, provides C2ES with expertise from across the economy, including the electric power sector, aluminum, cement, chemicals, automotive, oil and gas, manufacturing, finance, and information technology sectors. Our combination of policy and analytical expertise, longstanding relationships with leading businesses, and reputation as a trusted convener helps C2ES answer pressing questions, identify roadblocks to progress, and forge new solutions. We have long advocated for a technology inclusive approach to climate and energy issues, focused on the whole of our economy. We were among the first climate and energy organizations to advocate for policies, including the Section 45Q tax credit, which support the broad set of technology solutions needed to address climate change.

Carbon capture, utilization, and storage, as well as carbon removal technologies, must play a crucial role in helping to decarbonize the global economy. These technologies can cost-effectively address emissions from existing power and industrial facilities, help maintain power sector reliability, tackle hard-to-abate subsectors, and remove residual emissions to lower long-lived greenhouse gas concentrations. Leading the world in the development and deployment of these technologies supports the competitiveness of domestic cement, steel, and chemical sectors, while creating opportunities to export new technologies that can help the rest of the world decarbonize. Further, with early and continuous community engagement, their deployment can mean significant economic opportunity, including in regions that have been long involved in the production of fossil fuels. Recently enacted legislation, including the Energy Act of 2020 and the Infrastructure Investment and Jobs Act have both provided significant support for CCUS and carbon removal technologies. Yet, a comprehensive, long-term framework is needed to provide the comprehensive policy support needed to advance these technologies. This should include "upstream" policies to support innovation, including research, development, and demonstration; "downstream" policies that can help to create and grow markets for these technologies; and enabling policies and infrastructure that can provide a bridge to market for promising technologies.

There is strong scientific evidence in support of the potential and need for carbon capture and carbon removal technologies to meet our climate goals. The development of both technologies also offers a significant economic opportunity for the United States. Nonetheless, it's important to emphasize at the outset that these technologies are not silver bullets. CCUS technologies are vital tools to mitigate emissions, but they do not mean we can continue with business as usual. The deployment of these technologies will only succeed if we rapidly reduce our dependence on fossil fuels and accelerate the transition to zero-carbon forms of energy. Carbon removal technologies hold considerable promise as a vital means of balancing emissions from particularly "hard to abate" sectors, but in no way should be considered a substitute for reducing emissions across the economy as quickly as possible. As the impacts of climate change continue to mount, with extreme weather events affecting every region of the country, we must draw on all available means to successfully transition to the United States to a thriving, just, and resilient net-zero economy.

The importance of CCUS and carbon dioxide removal technologies in the U.S. climate toolkit

In a recent report on the role of carbon capture, utilization, and storage (CCUS) in the clean energy transition, the International Energy Agency (IEA) made it clear that "reaching net-zero will be virtually impossible without CCUS."[1] CCUS technologies have several important roles to play in decarbonization. CCUS technologies can be retrofitted to existing power and industrial facilities, which left unabated, would otherwise emit 600 billion tons of carbon dioxide over the next 50 years.[2] Moreover, keeping more firm, dispatchable power plants on the grid can help balance increasing quantities of renewable electricity, maintaining system reliability and avoiding the buildout (to some extent) of challenging, transmission infrastructure. CCUS can also help to address hard-to-decarbonize industrial sectors. For example, cement production would still emit carbon dioxide even if it were powered by clean energy sources since almost 60 percent of the carbon dioxide emissions from a cement plant are generated from the calcination process. Carbon capture will be needed to address these emissions. Further, CCUS technologies for mitigation provide a foundation for the development and deployment of carbon removal technologies that will be crucial to address residual emissions and lower, long-lived atmospheric concentrations to help avert the worst impacts of a changing climate.

Similarly, carbon dioxide removal technologies, including both nature-based removals (such as restoring forests and managing croplands and rangelands to store more carbon in soils) and engineered approaches

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[1] IEA, "CCUS in Clean Energy Transitions", 2020, https://www.iea.org/reports/ccus-in-clean-energy-transitions
[2] Energy Futures Initiative. "Workshop Summary: The Critical Role of CCUS: Pathways to Deployment at Scale." February 2021. https://static1.squarespace.com/static/58ec123cb3db2bd94e057628/t/603d3bd74d006a4004a9a88b/1614625758081/CCUS+Workshop+Summary+030121.pdf

such as direct air capture (DAC), have a vital role to play in meeting our net-zero goals. The National Academy of Sciences estimated that the United States needs to remove 1 gigatons of carbon dioxide per year by mid-century to reach net-zero emissions. This is equivalent to the carbon emissions of every coal plant in the United States, or the total emissions of Germany and the UK combined. Globally, we will need to scale these technologies to support 10 gigatons of carbon dioxide removal annually by 2050.[3] The work of the Intergovernmental Panel on Climate Change (IPCC) suggests most pathways to limit global warming to 1.5 degrees Celsius by the end of the century will include the use of carbon dioxide removal.[4]

Even with rapid scale-up of decarbonization efforts (e.g., renewable energy, electrification, energy efficiency, etc.), the United States will still need removal technologies such as direct air capture to meet its net-zero target by 2050. Given practical constraints on the scale of nature-based removals (e.g., available land area for afforestation and limits on the storage capacity of agricultural soils), engineered technologies will play a critical role. Depending on the pace of decarbonization, carbon dioxide removal technologies (e.g., direct air capture and bioenergy with carbon capture and storage) will be needed to cumulatively remove between 1.1 billion tons of carbon dioxide (rapid decarbonization scenario) and 1.9 billion tons of carbon dioxide (slow decarbonization scenario).[5] Of these sums, it is anticipated that direct air capture will need to account for roughly 50 to 90 percent of the total.[6]

The business and economic case for CCUS and carbon dioxide removal technologies

As markets increasingly demand low-carbon goods and products, the ability of companies to reduce emissions in the direct production of goods and services, as well as throughout their value chains, will be critical for U.S. companies to retain or even enhance their competitiveness. However, enabling private sector investment at the scale necessary will require policy that values the greenhouse gas emission reductions that these technologies provide. CCUS technologies can support those efforts, particularly in hard to abate sectors like cement, chemicals, metals, and aviation. We at C2ES have seen a great deal of leadership and interest from industrial companies in pursuing these technologies, including those in our Business Environmental Leadership Council, and through efforts like the Carbon Capture Coalition.

An important, emerging trend in the deployment of CCUS and carbon dioxide removal technologies is the shared utilization of transportation and storage infrastructure. Due to the lack of widespread deployment and diffusion of these technologies and their associated infrastructure, economic viability for projects often hinges on the ability to capitalize on economies of scale. This has generally meant that only larger scale projects were

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[3] National Academies of Sciences, Engineering, and Medicine (NASEM), "Negative Emissions Technologies and Reliable Sequestration: A Research Agenda"; The National Academies Press: Washington, DC, 2019, https://nap.nationalacademies.org/catalog/25259/negative-emissions-technologies-and-reliable-sequestration-a-research-agenda
[4] IPCC, "Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development. In: Global Warming of 1.5°C", 2018, https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_Chapter2_Low_Res.pdf
[5] Rhodium Group, "Capturing Leadership: Policies for the US to Advance Direct Air Capture Technology", 2019, https://rhg.com/wp-content/uploads/2019/05/Rhodium_CapturingLeadership_May2019-1.pdf
[6] ibid

likely to be economically viable. However, implementing a cluster approach, which involves the sharing of transportation and storage infrastructure, reduces individual project costs, and enables a far greater number of smaller projects to become economically viable. Shared carbon management infrastructure, like the interstate highway system can enable a vast amount of low-carbon commerce.

A vital component to the success of any CCUS or carbon dioxide removal project will be the early and continuous engagement of communities throughout the project lifecycle. Many of these projects, due to the location of power and industrial facilities, will be located near frontline communities which have been historically marginalized. Genuinely engaging and addressing the concerns of frontline and historically underrepresented stakeholders throughout the process can not only ensure that those communities – through mechanisms such as community benefits agreements – can share the benefits of these projects but can also meaningfully reduce community opposition to projects.

When built on a foundation of community engagement, CCUS and carbon dioxide removal projects can also provide significant economic benefits for communities, through job creation and associated tax revenues. A recent study estimated that carbon capture retrofits at existing industrial and power facilities could create up to 64,000 jobs between now and 2035 and as many as 78,000 additional jobs from 2035–2050.[7] It is also estimated that large-scale deployment of direct air capture, could create at least 300,000 new jobs across construction, engineering, and equipment manufacturing sectors.[8] And, these opportunities are widely dispersed across the country.

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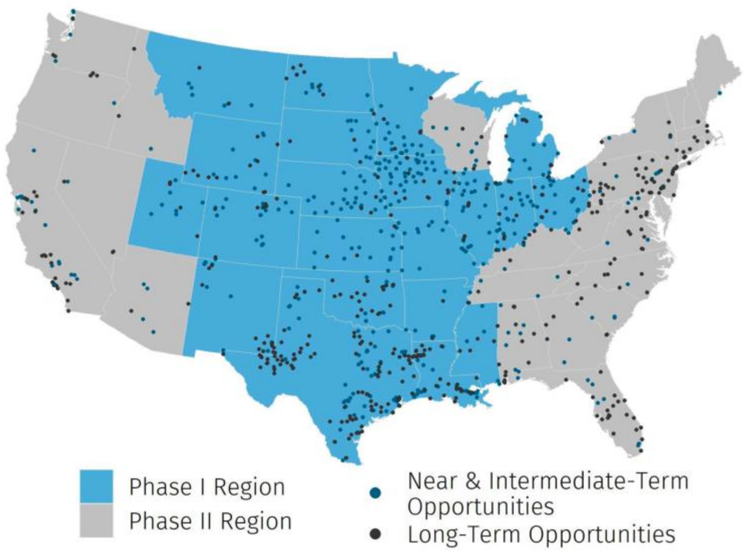
[7] Rhodium Group, "The Economic Benefits of Carbon Capture: Investment and employment opportunities for the contiguous United States", 2021, https://rhg.com/wp-content/uploads/2021/04/The-Economic-Benefits-of-Carbon-Capture-Investment-and-Employment-Opportunities_Phase-III.pdf

[8] Rhodium Group, "Capturing New Jobs: The employment opportunities associated with scale-up of Direct Air Capture (DAC) technology in the US", 2020, https://rhg.com/wp-content/uploads/2020/06/Capturing-New-Jobs-Employment-Opportunities-from-DAC-Scale-Up.pdf

Figure 1: Carbon capture retrofit opportunities at existing industrial and power facilities



Carbon capture retrofit opportunities at existing industrial and power facilities in the near- and intermediate-term (2021 – 2035) and long term (2036 – 2050). Phase I refers to industrial and power sector opportunities in 21 states in the Midwest and Western region that participate in the Regional Carbon Capture Deployment Initiative. Phase II refers to industrial and power sector opportunities in Eastern and Western States. The economic benefits considered include employment opportunities in construction (e.g., engineering, equipment, materials) and operations (e.g., maintenance, chemicals, energy, water treatment)

Source: Rhodium Group, 2021.

As we transition to a low-carbon economy, it is also important to recognize the contribution that communities and workers involved in the production and utilization of fossil fuels have and continue to make to our nation; we must support them and help them successfully navigate this transition. We should also recognize the value of the myriad skills and competencies that these communities can bring to the transition and look to align them with regionally salient low-carbon economic opportunities in emerging industries like CCUS and carbon dioxide removal. Many of the skills required for jobs in these sectors require similar skill sets to those in the mining and oil and gas sectors, making the emerging carbon management sector a great opportunity to facilitate the transition while leveraging, rather than sacrificing, years of knowledge and capacity building.

With proper support from policymakers, CCUS and carbon removal technologies can support the competitiveness of domestic industry in rapidly evolving global markets and encourage the utilization of shared infrastructure, while facilitating the community input and engagement that will be necessary to ensure a just and equitable transition.

Recent legislative developments

Congress has taken several important steps in recent years to support the development of CCUS and carbon dioxide removal technologies. The Energy Act of 2020 included a two-year extension of the Section 45Q tax credit, which provides incentives, in the form of tax credits, to encourage companies to invest in carbon capture and storage solutions that reduce carbon emissions to the atmosphere. The extension enables facilities that begin construction by 2025 to access this important credit. It also authorized more than $6 billion for ambitious research, development and demonstration provisions for carbon capture, removal, utilization, and geologic storage programs over a five-year period. Similarly, the bipartisan Infrastructure Investment and Jobs Act made the single largest investment in carbon management provisions in history. Specifically, it funded four key areas of carbon management policy: CCUS research, development, and demonstration (RD&D); carbon transport and storage infrastructure and permitting; carbon utilization development; and carbon removal. These important pieces of legislation have laid the groundwork for a growing carbon management sector to help the United States meet its mid- and long-term climate objectives, enhance the competitiveness of domestic industries and leverage the skills and ingenuity of American workers to capitalize on the economic growth opportunity that the transition to a net-zero economy can provide for communities across the country.

Policy will be essential to the deployment of CCUS and carbon removal technologies

To help keep the United States on track to reach net-zero by 2050, the current level of deployment of CCUS technologies must increase by a factor of ten by 2030.[9] While recent legislative developments have laid a vital foundation for CCUS and carbon removal technologies moving forward, to facilitate the necessary growth, more policy incentives are needed to attract even greater private sector investment and scale CCUS and carbon removal technologies.

A policy framework that supports the entire innovation ecosystem for these technologies is essential for their long-term development. Congress should 1) make further "upstream" investments in innovation, including research, development and demonstration, 2) enact "downstream" policies that can help to create and grow markets for these technologies, and 3) facilitate enabling policies and infrastructure that can provide a bridge to market for promising technologies. All three areas of policy are needed for success. Supporting technological innovation through RD&D spending, without creating market demand, will strand new technologies in the labs or at the demonstration phase. Providing market incentives without the necessary enabling policies risks letting deployment stall below its potential as projects run up against nonmarket barriers.

First, policymakers have made significant, recent investments in "upstream" innovation for the research, development and demonstration of CCUS and carbon removal technologies, particularly in the Infrastructure Investment and Jobs Act. It will be imperative to leverage and sustain these investments in innovative technologies. Further research into increasing the efficiency of separation technologies (liquid absorbents, solid adsorbents, membranes), regeneration and reuse of materials used to capture carbon dioxide, and the potential of hybrid separation systems can help to advance a broad range of technologies. Importantly,

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[9] National Academies of Sciences, Engineering, and Medicine, "Accelerating Decarbonization of the U.S. Energy System", 2021, https://nap.nationalacademies.org/catalog/25932/accelerating-decarbonization-of-the-us-energy-system

additional, expanded support for research and development of utilization approaches could help tap sizeable markets for products like low carbon fuels (utilization potential of 1,000–4,200 $MtCO_2$/year by 2050), chemicals (300–600 $MtCO_2$/year by 2050), and building materials (100–1,400 $MtCO_2$/year by 2050).[10]

Policymakers should also look to build on recent efforts in the Infrastructure Investment and Jobs Act to support four direct air capture hubs, to advance a regional, shared infrastructure approach for CCUS and carbon dioxide removal transportation and storage networks that can create opportunities to lower project costs and accelerate adoption and commercialization of new technologies. Coordinating and underwriting the development of industrial hubs can help advance these technologies and their associated benefits.

Second, a number of demand side, or "downstream" policies will also be needed to facilitate the growth of markets for carbon capture, utilization, storage, and removal technologies. Comprehensive, market-based approaches like carbon pricing would send an important signal across the economy, encouraging emission reductions, enhancing innovation and bolstering the impact of other policies by aligning economic incentives with decarbonization efforts. Over the long-term, a price on carbon will be an essential tool for advancing CCUS and carbon removal technologies.

Procurement policies which prioritize these products are a key lever for advancing the deployment of CCUS and carbon removal technologies. Offtake agreements, in which an off taker commits to purchasing all or a substantial portion of the output from a facility, can provide crucial revenue streams that support a project financing. Whether from the private or public sectors, procurement will be crucial to help these sectors, especially direct air capture, to grow at the speed and scales necessary to meet decarbonization goals and capitalize on emerging global markets for these technologies.

Significantly extending and expanding the Section 45Q tax credit would send an important, long-term market signal. Since the initial enactment of this tax credit, half of all global carbon capture and storage projects have been developed in the United States.[11] Policymakers should prioritize: extending the commence constructure deadline for carbon capture, direct air capture and carbon utilization projects through at least 2031; increasing the credit value for industry and power projects to $85/ton for storage in saline geologic formations, and; increasing the credit value for direct air capture projects to $180/ton, for storage in saline geologic formations. The Section 45Q tax credit has thus far been instrumental in making the United States a global leader in the deployment of CCUS and carbon dioxide removal technologies. But it could be further leveraged to maximize the potential of these technologies in the United States and further cement our global leadership on these important technologies.

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[10] Hepburn, C., Adlen, E., Beddington, J. et al., "The technological and economic prospects for CO2 utilization and removal", Nature 575 (November 2019): 87–97 https://doi.org/10.1038/s41586-019-1681-6

[11] Turan, G., Zapantis, A., et al., "Global Status of CCS 2021", (October 2021) Global CCS Institute, Washington D.C., 20037 https://www.globalccsinstitute.com/wp-content/uploads/2021/11/Global-Status-of-CCS-2021-Global-CCS-Institute-1121.pdf

Third, a suite of enabling policies and actions, including those to advance necessary infrastructure, will be needed to help bridge the gap between early innovation and full market diffusion of CCUS and carbon removal technologies. Crucially, policymakers should support and prioritize the facilitation of early and continuous engagement between companies and communities throughout a project's lifecycle and seek to credibly address community concerns, including those centered on non-carbon dioxide air pollutants. Further research will be crucial to better understand the impacts of CCUS retrofits on criteria air pollutants, which have and continue to represent significant pollution burdens for frontline communities. For example, a recent study on the impacts of adding carbon capture to a cement plant in Canada found significant reductions in sulfur dioxide (100 percent), nitrogen oxides (56 percent), and particulate matter (92 and 70 percent for PM_{10} and $PM_{2.5}$ respectively).[12] Helping to better characterize these impacts, across a range of technology applications will be crucial to building the community support that will ultimately be necessary to deploy CCUS technologies.

Policymakers should also prioritize support for the development of carbon management infrastructure, which needs to be accelerated as quickly as possible to enable these technologies to scale and reach the capture levels needed to meet long-term decarbonization goals. For example, scaling up and optimizing regional carbon transportation and storage infrastructure could help facilitate the capture and storage of more than 350 million tons of carbon dioxide annually, more than a fifteenfold increase of the current carbon capture rate in the United States.[13]

Policymakers also need to ensure transparent and efficient permitting processes that allow for meaningful public engagement can build the necessary confidence among investors and community stakeholders for the sector to grow. A crucial need is building administrative capacity at the state and federal levels to provide greater regulatory certainty and allow for significant growth in the sector. For example, building state regulatory capacity could support state primacy applications as part of EPA's Class VI well permitting program, which was established by the EPA to provide specific regulations for dedicated geologic storage of carbon dioxide. The Infrastructure Investment and Jobs Act made a significant down payment toward building this capacity at the state level, as well as within EPA, which should pay dividends over the next several years. Congress should monitor this effort and provide additional resources as necessary to support the sector as it grows.

Climate action and economic opportunity are aligned

Carbon capture, utilization, and storage, as well as carbon dioxide removal technologies have an indispensable role to play alongside urgent efforts to reduce greenhouse gas emissions as quickly as possible across our economy. Doing so will not only help us meet our long-term climate goals, but also enhance the competitiveness of domestic industries, particularly those with hard to abate emissions like steel, cement, and

[12] International CCS Knowledge Center, "Summary for decision makers on large-scale CCS on cement", 2021, https://ccsknowledge.com/resources/featured

[13] Great Plains Institute, "Transport Infrastructure for carbon capture and storage", 2020, https://www.betterenergy.org/wp-content/uploads/2020/06/GPI_RegionalCO2Whitepaper.pdf

chemicals. Building on recent, historic investments, Congress can and should provide additional support to capitalize on the alignment of climate and economic goals and ensure that the U.S. leads the world in the transition to a clean energy future.