Industrial Innovation Initiative

a partnership between Great Plains Institute and World Resources Institute

To: Department of Energy

From: Industrial Innovation Initiative
Contact: Gabrielle Habeeb
Address: 2801 21st Ave, S #220, Minneapolis, MN 55407
Phone: (815) 274-1817
Email: ghabeeb@gpisd.net

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Re: DE-FOA-0002660-RFI

Background

The U.S. Department of Energy has a crucial role to play in advancing critical carbon management technologies key to achieving industrial decarbonization by midcentury. In response to the Request for Information regarding Deployment Opportunities for Carbon Reduction and Removal Technologies (DE-FOA-0002660-RFI), the Industrial Innovation Initiative (I^3) has prepared the following document.

About I^3

The Industrial Innovation Initiative (I^3) is an ambitious coalition which aims to advance solutions key to decarbonizing the industrial sector by midcentury through policy development and implementation, technology demonstration and adoption, and demand-side market development at state, regional, and federal levels. I^3 builds on years of stakeholder engagement and work by Great Plains Institute (GPI) and World Resources Institute (WRI) with state officials in the Midcontinent region, as well as extensive work advancing decarbonization solutions important to the industrial sector. The Initiative convenes key industry, environmental, labor, and other stakeholders, together with state officials, to advance cross-cutting strategies, policies, and programs for achieving industrial decarbonization by midcentury.

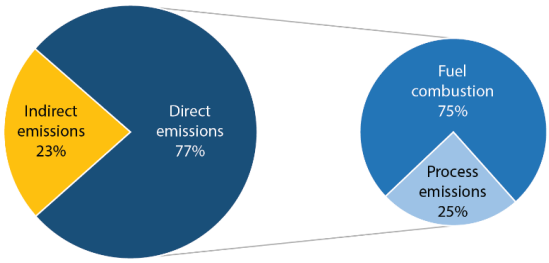
Introduction

Carbon Capture, direct air capture, carbon utilization, transportation, and storage are all vitally important to decarbonizing the industrial sector by midcentury. The industrial sector is essential to jobs and prosperity, producing materials that are central to many aspects of our everyday lives, from concrete and steel to chemicals and paper. Like all sectors economywide, emissions from the industrial sector need to decline significantly in the near- to medium-term to remain on track to meet midcentury decarbonization goals.

Industrial sector emissions include both direct and indirect emissions. Direct emissions account for about three-quarters of total U.S. industrial emissions. These emissions originate from the

on-site combustion of fuels as well as process emissions from chemical reactions inherent to industrial production itself. Direct emissions, especially process emissions, can be extremely difficult to eliminate as they are the result of the physical and chemical processes undergone during production (such as with steel, refining, and cement). Carbon capture and the beneficial utilization or geologic storage of industrial emissions offer the best solution for mitigating and reducing industrial process emissions.[i]

Breakdown of industrial emissions by type and origin



Industry contributes 23 percent of U.S. greenhouse gas emissions, making it the third highest-emitting sector after transportation and electricity. When emissions from industrial electricity use are included, the industrial sector emits 30 percent of total U.S. emissions.[ii]

Federal policy will play a vital role in overcoming a major sequencing challenge as carbon management begins to scale. Companies must be confident that necessary CO_2 transport and storage infrastructure will be developed before they will commit to siting capture projects; conversely, pipeline and storage developers will not proceed absent of confidence that future capture projects will be developed and placed in service. Federal funding can also help ensure that initial infrastructure is built with extra capacity up front to accommodate cost-effective future growth in carbon capture, direct air capture, and carbon utilization over time.[iii]

The path toward industrial decarbonization by midcentury is challenging but feasible; however, we need to spur meaningful action in the next ten years if we are to stay on track. Pilot and demonstration projects are useful for proving the technology, however, the time to scale these projects has come. Success requires support for carbon management solutions through federal policy and from implementing agencies like the Department of Energy.

Technical Area 1 – Point-source Carbon Capture Technologies and Integrated Capture and Storage Products

Point Source Carbon Capture Technology and Application

Carbon capture involves the installation of capture technology on industrial emissions sources and the transport of captured CO_2, via pipeline or other means, to locations where it can be put to beneficial use or geologically stored.

Carbon capture and the beneficial utilization and geologic storage of industrial emissions offer the best solution for mitigating and reducing process emissions which represent roughly 30 percent of industrial emissions. There are currently more than 84 carbon capture projects underway, of which 60 are categorized as industrial sector projects, including projects in the hard-to-decarbonize steel, cement, and petrochemical sectors. Carbon capture technology is a useful solution across sectors but is particularly critical for the decarbonization of industry. If these projects all proceed to commercial operation, it will put the U.S. on a pathway for a ten-fold increase in operating carbon capture projects over the next decade. Additionally, many more projects under development have not yet been publicly announced.[iv]

The 45Q tax credit provides a crucial incentive to bridge the gap between return on capital investment and the costs of capture, transport, and storage.[v] Industrial facilities, including direct air capture, are eligible if they capture at least 100,000 $MtCO_2$/CO per year. [vi] In the contiguous U.S., carbon capture has the potential to capture 195 $MtCO_2$/year in process emissions from 656 industrial facilities. Within these facilities, 458 facilities qualify for the 45Q tax credit, accounting for 188 $MtCO_2$/year.[vii] Enhancing economic incentives for carbon management will be necessary to drive down the cost of decarbonization long-term.

The recently enacted Infrastructure Investment and Jobs Act, marks a major step forward in fostering economywide deployment of carbon management technologies, and includes full funding for 2020 Energy Act authorizations to support commercial-scale demonstrations, pilots and engineering studies for carbon capture, direct air capture and carbon utilization technologies and investments in the development of regional direct air capture and hydrogen hubs. Large-scale pilot and demonstration projects are a key step to achieving our emissions reduction objectives and to driving near-term job creation and economic activity, while spurring additional project development and scaling. The infrastructure bill contains $8.6 billion in funding over five years for 2020 Energy Act authorizations for pilot, demonstrations and other deployment facing initiatives.[viii]

It is estimated that the provisions enacted by the infrastructure package, in tandem with proposed bipartisan enhancements to the 45Q tax credits in separate climate and energy legislation, would result in an estimated 13-fold increase in carbon management capacity and annual CO_2 emissions reductions of 210-250 million metric tons by 2035.[ix]

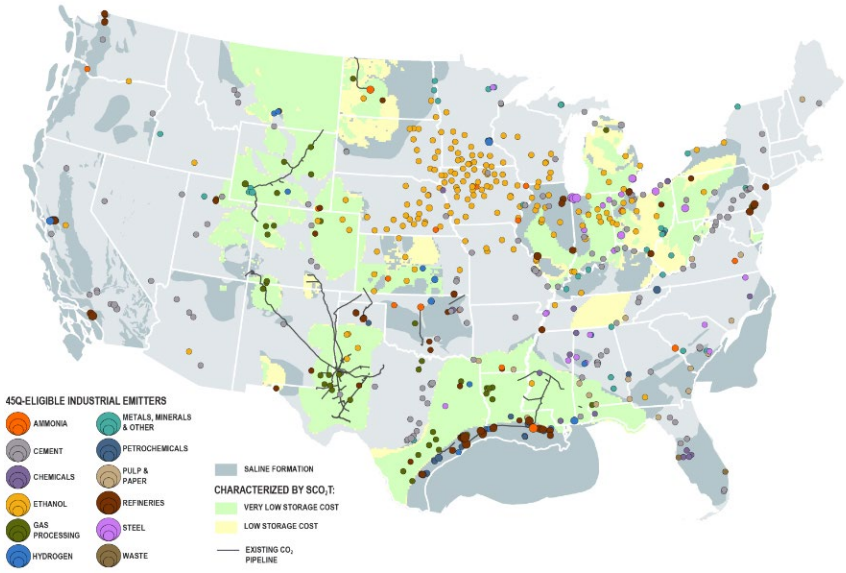
Technical Area 2 – Validation of Carbon Storage Resources for Commercial Development

Business Case for Geologic Storage Facility

Co-location of Direct Air Capture (DAC) or carbon capture hubs with storage site minimizes the costs associated with transport and land use. Many industrial facilities where carbon capture is applicable are located above or near sedimentary basins suitable for CO_2 injection and permanent geologic storage.[x] In the U.S., 276 industrial facilities with the potential to capture 83.2 $MtCO_2$/year are co-located with sedimentary basins suitable for injection. An additional 251 facilities with capture potential of 77.6 $MtCO_2$/year are less than 100 miles from a sedimentary basin.[xi]

Of the 84 publicly announced carbon capture projects, 71 percent of all projects are planning to store in dedicated saline storage sites.[xii] The map below shows the geographical distribution and the magnitude of 458 industrial facilities that were considered for carbon capture retrofit with geologic storage.

Geographical distribution of the CO_2 capture opportunities from industrial point sources in the U.S. along with geological storage opportunities



Source: Figure authored by GPI based on the SimCCS model, 2020.

The recently enacted Infrastructure Investment and Jobs Act fully funds the Storing CO_2 Emissions and Lowering Emissions (SCALE) Act, providing $25 million to support permitting of Class VI wells for geologic storage at The Environmental Protection Agency (EPA) and $50 million for state activities including a grant program for states to establish their own Class VI permitting programs.

The existing 45Q credit has significant limitations and improvements are needed to enable a greater number and diversity of carbon capture, direct air capture, and carbon utilization

projects to achieve commercial feasibility. The cause for greatest concern is that the 45Q credit value is insufficient to fund major new CO_2 transport and storage infrastructure. CO_2 pipelines and other infrastructure connected to large-scale saline geologic storage sites are necessary to transport CO_2 from the point of capture to where it can be securely stored or put to climate-beneficial economic use.[xiii]

Technical Area 3 – Carbon Dioxide Pipeline Infrastructure at the Regional and National Scale

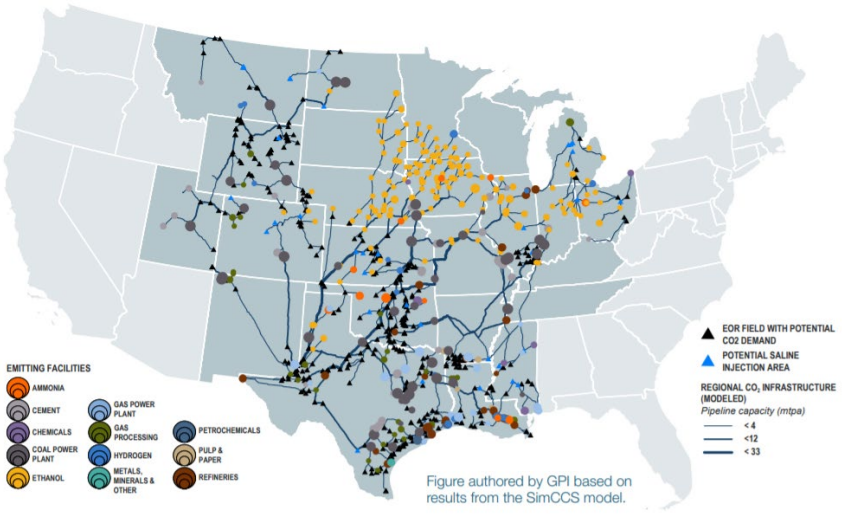
Description of Proposed Regional and National Pipeline System(s) for Carbon Dioxide

Carbon dioxide is an industrial commodity that is transported through regional pipelines to locations where it can be sold, commercially utilized, and geologically stored. Beneficial economies of scale may be achieved by shared long distance and high-capacity transport infrastructure to support economywide deployment of carbon capture equipment.

While some regions of the United States have suitable geological formations for CO_2 storage, there are many industrial and power facilities located in regions of the United States without significant deep saline or hydrocarbon geologic formations. Long distance transportation infrastructure can unlock emissions reductions from these facilities as well as economic benefits associated with CCUS projects and maintaining local industries.[xiv]

There are currently about 5,000 miles of CO_2 transport pipelines in the United States. Realizing economy wide deployment of regional CO_2 transport infrastructure will require significant buildout. Developing shared transport infrastructure connecting emitting sources to storage and utilization sites will minimize overall costs and land use impacts of deploying technologies. The figure below illustrates an optimized pipeline network through the midcontinent region.[xv]

Optimized transport network for economy-wide CO_2 capture and storage



The SCALE Act positions the federal government to partner with private capital to invest in both regional and national CO_2 transport and storage infrastructure networks. The SCALE Act is also technology agnostic, in that it can be applied to any form of transport, not just pipelines.[xvi] Multi-modal transport and distribution - inclusive of railroads, trucks, and barges - offers the near-term flexibility necessary to foster market scaling before pipeline networks are fully built. Areas that host concentrated industrial activity, geologic storage, and existing conventional fossil fuel distribution infrastructure which can be used for CO_2 transport infrastructure are prime candidates for carbon hubs.[xvii] Similar to existing rail, highway, power, water, and gas infrastructure for their respective industries, shared CO_2 transport and storage infrastructure facilitates carbon capture deployment in three key ways:

- Enabling more CO_2 capture from more places: not all regions of the U.S. have suitable geology for storage, so CO_2 must be transported to regions that do. Storage hubs in suitable regions can store CO_2 from numerous sources across a wide area.
- Realizing economies of scale: CO_2 transport and storage infrastructure have strong economies of scale whereby larger infrastructure handling greater CO_2 volume has lower unit cost per ton of CO_2. Aggregating more CO_2 from more sources decreases transport and storage costs, which in turn enables more carbon capture deployment.
- Connectivity: Creating a CO_2 market will lower risk. Shared CO_2 infrastructure systems will connect multiple buyers and sellers of CO_2. Such markets would decrease the demand or supply risk for any individual capture, utilization, or storage project, thereby reducing financing risk premiums and the total cost of carbon capture. Connectivity would also unleash the power of markets to drive innovation in technology and business models, inevitably accelerating carbon capture deployment.

Federal investment in CO_2 transport infrastructure must support development of an interconnected, open-access CO_2 transport system in the United States that is able to serve future needs for CCUS scale-up. The SCALE Act[xviii] provides DOE with key tools to achieve this need:

- The Large-Scale Carbon Storage Commercialization Program enables DOE to invest in developing CO_2 storage sites to receive CO_2 from capture and removal projects under development.
- The CIFIA (CO_2 Infrastructure Finance and Innovation Act) program requires CO_2 transport infrastructure be a common carrier to ease access.
- The CIFIA program's Future Growth Grants enables DOE to invest to ensure key new CO_2 pipelines are built to meet future demand as CCUS scales up.

Technical Area 4 – Direct Air Capture (DAC) Technologies and Regional Deployment Opportunities

Direct Air Capture (DAC) will become increasingly important in decarbonizing particularly hard-to-abate industries where CO_2 is not easily captured at the point of emission. DAC also provides a vital solution for the removal of CO_2 from the atmosphere. Even under an ideal scenario where the U.S. fully decarbonizes the economy by midcentury, direct air capture and other negative emissions technologies will play a significant role in offsetting any remaining anthropogenic emissions. The International Energy Agency (IEA) estimates that the global carbon management industry will need to scale up to well over 2,000 facilities, capturing 2.8 gigatons of CO_2 per year to limit warming to 2°C.[xix]

The four regional Direct Air Capture (DAC) hubs, as funded by the Infrastructure Investment and Jobs Act, should be sited based on criteria where there is the greatest potential for effective synergies at each phase of the carbon management process. Statutory criteria include the capacity to remove at least 1 million tons CO_2 annually, with priority for projects with larger initial capacity and greater potential for expansion; potential to help facilitate regional CCUS networks; synergies with CO_2 storage hubs; and potential to serve point-source CO_2 capture projects (beneficial for realizing economies-of-scale and mitigating the chicken-and-egg challenge for sequencing buildout of CO_2 capture, transport, and storage projects). DAC Hubs should also be located within regions with existing carbon-intensive industry or fossil fuel production and provide benefits to communities beyond climate change mitigation, such as providing new employment and economic opportunities for legacy energy communities. There may also be synergies between DAC Hubs and deployment of other clean energy technologies, such as low emissions power, hydrogen, and CO_2 utilization.[xx]

When considering siting DAC hubs near 45Q tax credit qualifying facilities, it is also beneficial to include facilities with near- and medium-term capture opportunities, looking both at the carbon capture landscape which exists and where it is trending long-term.[xxi]

Technical Area 5 – Direct Air Capture Prizes and Requirements

To spur advancements in DAC and its deployment, the federal government can create competitions or challenges in which they develop ambitious performance criteria and establish a prize for the entity that first meets the challenge (or all entities that meet the challenge).[xxii] Prizes currently funded under the Infrastructure Investment and Jobs Act for DAC consist of a financial award: $100 million for the commercial DAC prize and $15 million for the pre-commercial DAC prize. The commercial DAC prize, as it is structured for a per-ton payment for CO_2 removed, can be used to provide long-term revenue certainty for commercial DAC projects to facilitate financing.

Technical Area 6 – Opportunities for Carbon Conversion Technologies and Grant Program

Funding, Business Models, and Market Considerations

In the industrial sector especially, capital costs are high, and the economic life of assets is measured in decades, making it difficult for companies and their investors to shoulder the risks of early commercial-scale demonstration on their own. There is, therefore, a need to increase federal investment in research, development, commercial-scale demonstration, and deployment.

Carbon utilization entails the beneficial use of CO_2 or CO captured from gaseous waste streams in the manufacture of a valuable product that results in a net reduction of greenhouse gas emissions as compared to an incumbent process or product. Carbon utilization may involve the production of a wide variety of commodities or products sourced from waste gases or direct air capture, including low- and zero-carbon fuels, chemicals, plastics, advanced materials, industrial gases and fluids, building products, and even feedstocks for animal feed and food. Using the IRS definition of commercial markets, a wide variety of products sourced from qualified carbon oxides should be eligible to receive credit under 45Q.

High-volume products sourced from carbon utilization, including concrete, aggregates, and fuels could drive both significant carbon utilization and market value. However, realizing this market will require a range of market development policies such as federal procurement, buildout of CO_2 transport infrastructure, and breakthroughs in carbon utilization technologies and processes enabled by federal RD&D. The federal government can take steps to incentivize commercial production of products sourced from carbon capture, including developing standards and disclosures regarding the embodied carbon content of carbon recycled products. As corporations and other entities begin to look towards procurement of electricity, liquid fuels and products sourced from carbon capture processes, the federal government can play a leading role in developing standards for what is needed to track, account for, and verify carbon reductions from the manufacture of such products.[xxiii]

Engagement and Existing Government Procurement Mechanisms

Federal and state governments can put in place procurement bonus policies that encourage companies to outperform each other on low-carbon innovation. A procurement bonus provides a cost discount to a company's bid if it has lower carbon intensity than its competitors. Another option is to also include a fund that covers the cost differential (if any exists) between the winning low-carbon bids and the bids that use conventional technologies. A high-achievers program could also provide a voluntary certification to manufactured materials that meet a defined specification for lower greenhouse gas emissions intensities (similar to the EnergyStar approach for energy efficiency). This type of voluntary certification could then be used as a requirement for some percentage of federal or state purchasing, and as a voluntary benchmark for private sector procurement and consumer-facing programs. This enables agencies or departments to use low-carbon options without having to cover any additional costs through their operational budgets.[xxiv] Manufacturing that makes use of captured carbon has the

potential to be more costly compared to traditionally produced products. Procurement mechanisms can lend certainty and stability to industry leaders.

In actualizing procurement mechanisms, we should first support information and disclosure policies. A clear and comparable data set is a necessary starting point for setting meaningful emissions intensity benchmarks for any voluntary or mandatory industrial procurement policy. Given the low level of comparable data in many industrial sectors, disclosure of emissions intensity data through environmental product declarations (EPDs) or other independently verified reporting mechanisms, following a consistent scope and methodology, should be the first step to build towards other procurement policies at the federal or state level.[xxv]

Technical Area 7 – Environmental Justice, Engagement, and Workforce Development

Investments in carbon capture, direct air capture, and carbon utilization projects, together with accompanying CO_2 transport and storage infrastructure, have the potential to help revitalize and sustain communities reliant on traditional energy production and industries. Carbon capture projects provide some of the most desirable clean energy and industrial jobs as employment associated with hard to abate industrial sectors pay higher than average local wages. Residents of historically disadvantaged communities living close to industrial and power generation facilities have borne disproportionate impacts of pollution while often lacking access to the high-wage jobs these facilities provide. Carbon management projects have the potential to change this dynamic.[xxvi]

The communities that are most vulnerable to climate change also typically suffer the greatest impacts from criteria air and other pollutants from nearby industrial and power facilities; carbon capture can play a role in addressing these concerns. Carbon capture is a flexible control technology that works on a wide range of industrial facilities and power plants, and in many instances carbon capture retrofits significantly reduce conventional pollutant emissions. Prior to CO_2 separation and capture, flue gas must undergo pretreatment to remove criteria air pollutants, including sulfur oxides, particulate matter, and nitrogen dioxide, to protect the capture solvent. Additionally, beneficial utilization of pre-combustion industrial gases removes criteria pollutants as part of the utilization process. Installation of carbon capture may also result in facilities having to meet more current and usually stricter emissions standards.[xxvii]

As carbon capture retrofits are capital intensive, it is less likely that old, inefficient, and higher polluting facilities are extending their lives by adding carbon capture. Younger, relatively more efficient, long-lived plants pose the most significant challenge to decarbonization, as without capture they will emit CO_2 unabated, potentially for decades. However, more detailed analysis is needed to quantify potential air quality benefits from such carbon capture retrofits.[xxviii]

It is also important to note that Tribal Nations are disproportionately negatively impacted by climate change, as shifts in climatic conditions impair and degrade the cultural, provisioning,

and regulating ecosystem services upon which their lives and livelihoods depend. Tribal Nations should be included as vital partners in all decisions made regarding carbon management on Tribal Lands, with a streamlined engagement process that incentivizes participation so they may ensure their benefit from these projects.[xxix]

Technical Area 8 - Iron, Steel, Manufactured Products, or Construction Materials and Clean Energy Jobs

Carbon Reduction and Removal Technology Deployment and Demonstration Projects Impacts on the Workforce

The industrial manufacturing sector, which includes the production of metal, mineral, chemical, and petroleum products, among others, currently makes up more than 11 percent of the U.S. GDP, making it the fourth largest contributor after Finance, Government, and Professional Business Services.[xxx] This sector employs millions of Americans and supports state and local economies across the Midwest and Gulf Coast. However, it is also the third largest emitting sector after electric power and transportation. Decarbonization must occur in a way that preserves industries and their contributions to the U.S. economy, as well as the direct and indirect jobs they create.

Deployment of carbon capture, removal, transport, utilization, and storage technologies will sustain and grow domestic high-wage industrial, energy, and manufacturing jobs. Carbon capture projects at industrial facilities and power plants provide some of the most desirable clean energy and industrial jobs since employment associated with heavy industry (refining, chemicals, cement, steel, etc.) and power plants pay higher than average local wages, while preserving important existing facilities and infrastructure.[xxxi]

A Rhodium Group analysis, commissioned by the Great Plains Institute, found that the anticipated industrial sector deployment of carbon capture, storage, and buildout of associated CO_2 transport infrastructure is expected to create up to 17,000 annual project-related jobs and 13,000 jobs for ongoing annual operations, with nearly $52 billion in capital investments through 2050.[xxxii]

Many additional high-wage jobs are created locally and across supply chains through the sector-wide deployment of carbon management technologies. A typical direct air capture plant capturing one million metric tons of CO_2 per year can generate roughly 3,500 jobs across the various sectors in the supply chain. The construction, engineering and equipment manufacturing sectors combined could see at least 300,000 new jobs associated with full scale direct air capture deployment, according to a Rhodium Group analysis.[xxxiii]

Conclusion

Industry presents a unique challenge to and opportunity for decarbonization. The industrial sector is responsible for approximately one third of U.S. carbon emissions and presents significant obstacles to decarbonize. The deployment of carbon capture and removal technologies have the potential to mitigate the worst of these emissions when deployed at scale, and support the continued operation of domestic manufacturing facilities, while creating and maintaining jobs which are critical to state and local economies in America's heartland. With emissions reductions may also come a myriad of economic, community, and public health co-benefits, so long as buildout is done with intention.

The U.S. is the world's leader in the capture, use and storage of carbon emissions, with nearly 50 years of successful commercial and operational experience across multiple sectors to leverage in building new industries and associated high-wage jobs. Building on the deeply bipartisan success of the 2018 Furthering Carbon Capture, Utilization, Technology, Underground storage, and Reduced Emissions (FUTURE) Act and subsequent bipartisan tax and research, development, and demonstration provisions in the 2020 omnibus, the Biden administration and the 117th Congress have the opportunity enact a broad portfolio of federal incentives and other policies to commercialize carbon capture, removal, transport, use and storage.

Extensive deployment of carbon management solutions will be necessary to offset the hardest-to-abate anthropogenic emissions and remove existing emissions from the air directly. With federal support, carbon capture, usage, and storage, and direct air capture technologies can and must be scaled up rapidly over the next decade if the U.S. is to do our part in maintaining a livable climate.

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