Federal Energy RD&D: Carbon Removal

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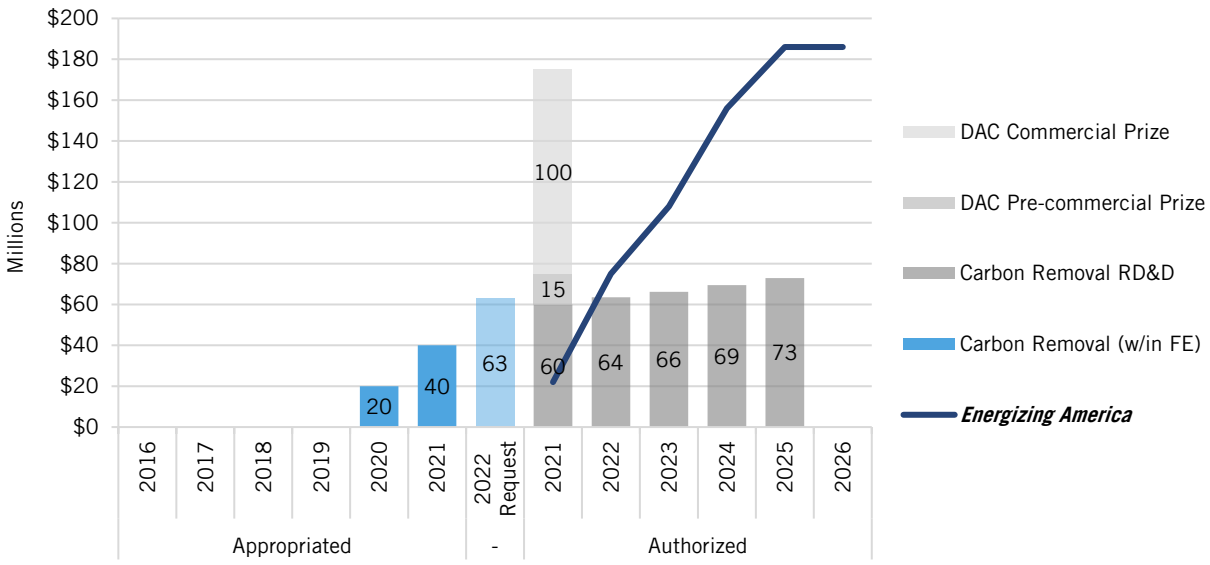
Carbon removal—sometimes called "negative emissions technologies"—refers to a suite of technologies and practices that remove carbon dioxide (CO_2) directly from the atmosphere for subsequent use or storage. Carbon removal is distinct from carbon capture, utilization, and storage (CCUS) and other conventional mitigation approaches because it removes CO_2 that is already in the atmosphere, rather than preventing the gas from being emitted in the first place.[1] The Energy Act of 2020 authorized the Department of Energy (DOE) to conduct research, development, and demonstration (RD&D) activities relating to direct air capture and storage (DACS), bioenergy with carbon capture and storage, enhanced geologic weathering, agricultural practices, forest management, and planned or managed carbon sinks.[2]

Figure 1: The Energy Act of 2020 directs DOE to establish a new Carbon Removal Program.[3]



What's at Stake

Removing CO_2 from the atmosphere and sequestering it permanently is no longer an option—it is a necessity. The 2018 Intergovernmental Panel on Climate Change (IPCC) found, "All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal on the order of 100 [gigatons]–1,000 gigatons of carbon dioxide ($GtCO_2$) over the 21st century."[4] But carbon removal is likely essential even for more relaxed targets. According to the IPCC, the median amount of carbon removal needed for pathways that limit warming to 2°C is 670 $GtCO_2$ by 2100, which is the equivalent of more than 100 times the total U.S. greenhouse gas emissions in 2019 (6.6 $GtCO_2$).[5]

Carbon removal addresses two essential challenges for deep decarbonization that other conventional mitigation approaches cannot. First, it is needed to offset residual emissions, especially non-CO_2 gases, that are impossible or prohibitively expensive to completely eliminate. For example, even the most aggressive decarbonization scenarios still include methane and nitrous oxide from agriculture.

Second, carbon removal provides a hedge against a carbon budget overshoot, which would occur if emissions did not decline quickly enough to avoid unacceptable and severe climate impacts. In this case, global average temperature rise would temporarily exceed some agreed-upon limit (e.g., 1.5°C or 2°C) before being brought down through net-negative emissions—i.e., when annual carbon removal exceeds residual emissions.

Unfortunately, no carbon removal technologies have been deployed at a scale that can meaningfully address the magnitude of global climate pollution. Approaches that manage natural ecosystems, such as afforestation and coastal restoration are low-cost, near-term options but have limited sequestration capacity, draw down atmospheric CO_2 too slowly to shape the path of climate change, and run into competition for land use. Technological approaches such as DACS, carbon mineralization through enhanced geologic weathering, and bioenergy with carbon capture and storage (BECCS) are relatively immature and expensive but have the potential to permanently remove large amounts of atmospheric CO_2.[6]

In October 2018, the National Academy of Sciences, Engineering, and Medicine (NASEM) released a detailed research agenda for carbon removal technologies, along with recommended funding levels to address each of the identified needs.[7] Many other scientific and advisory bodies have also recommended greater investment in carbon removal research, reflecting a growing consensus that carbon removal is important for achieving global climate goals.[8] In 2019, the Energy Futures Initiative (EFI) released the follow-on report *Clearing the Air* which provides a set of detailed implementation plans for the NASEM recommendations, including agency funding levels and program structures for a comprehensive 10-year $10.7 billion carbon removal innovation program that includes demonstration projects.[9]

Congressional appropriators have directed DOE to begin small-scale research efforts on direct air capture (DAC), carbon mineralization, bioenergy with carbon capture and storage (CCS), and other carbon removal approaches in the past few budget cycles.[10] In FY 2021 appropriations, Congress directed DOE to invest a total of $82.5 million in carbon removal across three offices: $40 million in the Office of Fossil Energy (FE), of which at least $15 million is for DAC; $20 million in the Office of Energy Efficiency and Renewable Energy to support DAC manufacturing technologies and algal carbon capture; and $22.5 million in the Office of Science.[11] In March 2020, FE released a new funding opportunity to provide $22 million in research for DAC.[12] However, current investments are too small to meaningfully address all carbon removal RD&D needs.

The Energy Act of 2020 authorizes the creation of a new Carbon Removal Program at DOE, which is a significant expansion and elevation of carbon removal research. The bill authorizes a new Direct Air Capture Prize Competition, with funding for both pre-commercial and commercial projects. The bill also directs DOE to establish one or more Direct Air Capture Test Centers and encourages DOE to support carbon removal pilot and demonstration projects.[13]

Figure 1 shows the FY 2022 budget request and the Energy Act of 2022 authorized funding levels for the new Carbon Removal Program. Funding for the pre-commercial and commercial DAC prize competitions is authorized in FY 2021, to remain available until expended. The carbon removal RD&D activities are authorized at $60 million in FY 2021, increasing to $73 million in FY 2025. The blue line shows recommended funding levels from the *Energizing America* report, which is adapted from *Clearing the Air*.

Box 1: An Innovation Agenda for Carbon Removal

The *Energizing America* report coauthored by the Information Technology and Innovation Foundation (ITIF)and Columbia University's Center on Global Energy Policy offers the creation of new federal programs to accelerate the development of carbon removal technologies.

- Congress should establish a comprehensive interagency RD&D initiative that implements the recommendations of the National Academies report on carbon removal. EFI provides a set of detailed implementation plans that include agency funding levels and program structures for a comprehensive 10-year, $10.7 billion carbon removal innovation program that includes demonstration projects.
- Congress should expand funding for the Carbon Removal Program at DOE, consistent with the levels recommended in the National Academies and EFI reports, and should encourage coordination with other parts of DOE. DOE should initiate an intra-agency working group to coordinate activities between the Carbon Removal Program, Carbon Capture and Carbon Storage programs in FE, Basic Energy Sciences (BES), Bioenergy Technologies Office (BETO), Advanced Research Projects Agency-Energy (ARPA-E), and other parts of DOE with relevant expertise.
- The White House should establish an interagency working group (IWG) to coordinate research between DOE, National Science Foundation, U.S. Geological Survey, U.S. Department of Agriculture, and other relevant agencies.

Carbon Removal RD&D Activities

The Carbon Removal Program was established in the Energy Act passed by Congress in December 2020. DOE has not yet announced plans for how the office and RD&D activities will be structured. The Energy Act authorizes funding for three broad activities: a prize competition for pre-commercial air capture; a prize competition for commercial applications of DAC; and carbon removal RD&D.

Key Elements of the FY 2022 Budget Proposal[14]

The budget proposal establishes a new Carbon Dioxide Removal subprogram that builds on past CCUS efforts by DOE. It would be funded $63 million and would focus on DAC materials and components, BECCS for both gasification and combustion, and enhanced carbon mineralization concepts.

ENDNOTES

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