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Carbon Capture Versus Direct Air Capture

Carbon capture and direct air capture (DAC) have gained prominence in recent years as options to address climate change. The two technologies have similarities (beyond their names), but they also have differences. Key differences include how the technologies work, where the technology can be used, how the technology can address climate change, and levels of federal support.

Several major energy proposals in the 116th Congress would increase federal support for carbon capture and DAC. Examples include the Senate energy package debated on the floor in March 2020 (S.Amdt. 1407 to S. 2657) and the Climate Leadership and Environmental Action for our Nation's Future Act (CLEAN Future Act) discussion draft released by leaders of the House Energy and Commerce Committee in January 2020.

This analysis explains key differences between the two technologies to inform congressional deliberations.

How Do They Work?

Carbon capture technologies prevent the release of carbon dioxide (CO_2) to the atmosphere. In the most commonly used arrangement today, a chemical that can "grab" CO_2 is placed in or near the stream of CO_2 at a source. The captured CO_2 is then released and compressed so that it can be transferred by pipeline. The CO_2 can then be used, for example, as a feedstock to an industrial process or permanently stored (sequestered) underground. The chemical that does the capturing can be reused in the process many times. The full process is called carbon capture, utilization, and storage (CCUS), or sometimes carbon capture and storage (CCS).

Direct air capture technologies remove CO_2 from the atmosphere, even if that CO_2 was released many years ago. In many technological approaches, air is forced over a chemical that can "grab" CO_2. DAC and CCUS may use the same chemicals, but some chemicals are better suited for one application or the other. Regardless, the supporting equipment must be optimized for the different CO_2 concentrations involved in DAC and CCUS. After capture, the process for DAC is very similar to that used for CCUS and can use the same equipment for compression, transfer, and storage. The chemical that does the capturing can be reused for DAC many times.

Both technologies are in early stages of development, with a few examples of operating projects worldwide. Of the two, CCUS is more mature, though researchers expect significant technology advancement can still be achieved.

Although the capture technologies are different for CCUS and DAC, they face similar challenges. Both are typically capital-intensive and energy-intensive. Also, the demand for CO_2 is small compared to its availability, resulting in low CO_2 revenues. The low value of CO_2 presents a hurdle to commercialization for both technologies.

Where Can They Be Used?

CCUS can be used at stationary sources of CO_2 such as power plants, ethanol production plants, or other industrial facilities. Existing facilities can be retrofitted to add CCUS equipment, or CCUS can be integrated into the design of new facilities. The type of source can affect the cost of a project because different sources emit CO_2 in different concentrations (purities). All else being equal, carbon capture can be completed at lower cost per ton CO_2 captured for sources with higher-purity CO_2 emissions (e.g., ethanol production plants). Sources of captured CO_2 are often located far away from where CO_2 may be used or stored, creating logistical and cost challenges related to the transport of CO_2.

DAC can be used anywhere. Many proposals envision building DAC projects close to either inexpensive electricity sources or locations where CO_2 can be used or stored. Both options could serve to lower overall project costs.

How Can They Address Climate Change?

CCUS would *reduce* CO_2 *emissions* released to the atmosphere. The extent of reduction is dependent upon the end use of the CO_2. Currently, the main use of captured CO_2 is for enhanced oil recovery (EOR). In EOR, compressed CO_2 is injected into aging oil wells. This process increases oil production while also permanently sequestering some CO_2.

Many stakeholders see CCUS as a way to enable continued use of fossil fuels even if CO_2 emissions were restricted in the United States and abroad. Fossil fuels have operational advantages over alternative fuels in many economic sectors. For example, cement, steel, and petrochemical manufacturing all require very high temperatures, currently provided almost exclusively by fossil fuel combustion. CCUS may allow continued use of fossil fuels in these and other sectors with lower CO_2 emissions than today.

DAC would *remove* CO_2 from the atmosphere. It is one example of carbon removal, sometimes called negative emissions technologies. Proponents see DAC and other carbon removal options as a way to reduce atmospheric CO_2 concentrations to desired levels. Some studies estimate DAC and other carbon removal options (e.g., afforestation) would need to be deployed at large scales globally to achieve climate targets investigated in those studies.

What Federal Support Exists?

Beginning in the late 2000s, the Department of Energy's (DOE's) coal research shifted to CCUS, particularly capture technologies and geological sequestration. These research, development, and deployment (RD&D) programs are authorized primarily by the Energy Policy Act of 2005 (P.L. 109-58) and the Energy Independence and Security Act of 2007 (P.L. 110-140). DOE's Office of Fossil Energy Research administers these R&D programs, with a focus on improving CCUS efficiencies and reducing costs. In the 2005 law, Congress directed DOE to focus on technologies to capture CO_2 from coal combustion, especially at power plants. In the 2007 law, Congress expanded the program direction to include sequestration research, testing, and demonstration.

Total appropriations since 2005 for CCUS-related RD&D exceed $6 billion. Of this amount, $3.4 billion came from the American Recovery and Reinvestment Act of 2009 (ARRA; P.L. 111-5). Much of the ARRA appropriation was to fund demonstration projects and had to be spent by FY2015. Of the $3.4 billion from ARRA, approximately $1 billion went unspent.

The Trump Administration has proposed cutting funding for CCUS RD&D. The Administration has stated a preference for focusing DOE resources on early-stage research and relying on the private sector to fund later-stage activities such as demonstration projects. Congress has rejected such proposals and instead funded CCUS RD&D at or above historic levels with a continued focus on both early-stage and later-stage RD&D activities. Presidential budget requests and annual appropriations for CCUS RD&D for FY2018-FY2021 are shown in **Table 1**.

Table 1. Funding for DOE CCUS Research, Development, and Demonstration, FY2018-FY2021 Request

in millions

DOE Program Area	FY2018	FY2019	FY2020	FY2021
Carbon capture (requested)	$16	$20	$40	$74
Carbon capture (enacted)	$101	$101	$118	N/A
Carbon storage (requested)[a]	$15	$20	$26	$45
Carbon storage (enacted)	$98	$98	$100	N/A

Source: U.S. Department of Energy annual budget justifications for FY2018 through FY2021.

Notes: CCUS = carbon capture, utilization, and storage; N/A = not applicable. Figures are rounded to the nearest million. Carbon capture and carbon storage are the two program areas specified in appropriations documents most related to CCUS, though other program areas may fund related research.

a. The FY2019, FY2020, and FY2021 budget requests proposed merging the carbon capture and carbon storage accounts into a single carbon capture, utilization, and storage account. For comparison purposes, this table combines the requested budgets for carbon utilization and carbon storage into the carbon storage line.

DAC has not been a focus area for DOE research to date, although Congress, in the explanatory statement for FY2020 appropriations, did direct DOE to use at least $10 million of its appropriation for DAC research. DOE research on systems shared by both technologies (e.g., compression, underground storage) could benefit DAC projects moving forward.

CCUS and DAC projects are both eligible for federal tax credits proportional to the amount of CO_2 they use or store. Congress established these tax credits in 2008 and expanded them in 2018. Under current law, eligible projects may receive tax credits up to $50 per metric ton CO_2. Projects must meet certain requirements such as minimum capture amounts, monitoring procedures, and start-of-construction deadlines. Some Members of Congress have proposed changes to these requirements.

Bills have been introduced in the 116th Congress that would increase direct federal support for CCUS and DAC. Proposals include expanding DOE's RD&D activities and establishing technology prize competitions. Bills have also been introduced in the 116th Congress that could indirectly support CCUS and DAC. These proposals include carbon taxes, clean energy standards, and low carbon fuel standards.

Additional Resources

Tax credits for which CCUS and DAC may be eligible are discussed in CRS In Focus IF11455, *The Tax Credit for Carbon Sequestration (Section 45Q)*.

CCUS technology and existing U.S. projects are discussed in CRS Report R44902, *Carbon Capture and Sequestration (CCS) in the United States*.

Past appropriations for CCUS are discussed in CRS In Focus IF10589, *FY2019 Funding for CCS and Other DOE Fossil Energy R&D*.

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