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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.

Congress affirmed its support for these technologies in Section 40301 of the Infrastructure Investment and Jobs Act (IIJA; P.L. 117-58): "carbon capture and storage technologies are necessary for reducing hard-to-abate emissions from the industrial sector, which emits nearly 25 percent of carbon dioxide emissions in the United States ... carbon removal and storage technologies, including direct air capture, must be deployed at large-scale in the coming decades to remove carbon dioxide directly from the atmosphere ... large-scale deployment of carbon capture, removal, utilization, transport, and storage—is critical for achieving mid-century climate goals; and will drive regional economic development, technological innovation, and high-wage employment."

The following analysis explains key differences between the two technologies to inform ongoing congressional deliberations regarding the merits of these technologies, rationale for federal support, and funding level considerations. Additional information, such as costs and other challenges, is provided in other CRS resources, listed below.

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 used repeatedly in the process. 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 each application. 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 also be used repeatedly.

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 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 of 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, reducing overall costs.

How Can CCUS and DAC 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.

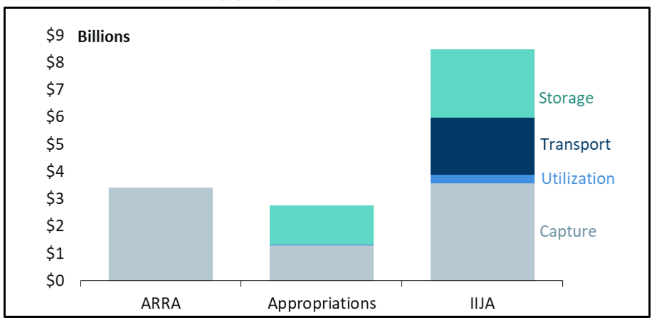
DAC would *remove* CO_2 from the atmosphere. It is one example of carbon removal, sometimes called negative emissions technologies. Proponents see DAC and other carbon removal options as a way to reduce emissions from so-called hard-to-abate sectors (i.e., those for which non-emitting energy sources are not readily available and for which CCUS is not well suited). Additionally, DAC and other carbon removal options can potentially return atmospheric CO_2 concentrations to desired levels in case emissions reductions do not or cannot achieve those 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?

Congress has provided two main types of support for CCUS and DAC to date—research funding and tax credits.

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), the Energy Independence and Security Act of 2007 (P.L. 110-140), and the Energy Act of 2020 (Division Z of P.L. 116-260). DOE's Office of Fossil Energy and Carbon Management (FECM) 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. In the 2020 law, Congress further expanded the program to natural gas-fired power plants and other industrial facilities, and authorized a carbon utilization RD&D program.

Figure 1. CCUS Appropriations Since 2009



Source: U.S. Department of Energy annual budget justifications for FY2009-FY2021; explanatory statement for Consolidated Appropriations Act, 2021 (P.L. 116-260); IIJA (P.L. 117-58).

Notes: ARRA = American Recovery and Reinvestment Act of 2009; Appropriations = regular appropriations to CCUS-specific budget accounts, FY2009-FY2021; IIJA = Infrastructure Investment and Jobs Act. Some ARRA funding went to transport and storage activities; some ARRA appropriations went unspent. FY2021 regular appropriations includes $23 million for utilization. IIJA funding is FY2022-FY2026, some of which is available until expended.

Congress appropriated $2.7 billion to CCUS-specific FECM budget accounts between FY2009 and FY2021 through regular appropriations. Additionally, Congress provided large (relative to regular appropriations) appropriations to CCS demonstration projects in the American Recovery and Reinvestment Act of 2009 (ARRA; P.L. 111-5) and IIJA. ARRA provided $3.4 billion, mostly for demonstration projects, requiring projects to spend the money by FY2015. Approximately $1 billion went unspent. IIJA provides almost $8.5 billion for CCUS activities for FY2022-FY2026, including $2.1 billion for the establishment of a new Carbon Dioxide Transportation Infrastructure Finance and Innovation (CIFIA) program.

DAC has not been a focus area for DOE research historically, although Congress has recommended various DAC RD&D activities in recent appropriations. Additionally, Congress directed the Department of Defense to use $8 million of its FY2020 appropriation and $9 million of its FY2021 appropriation for DAC research. The Energy Act of 2020 authorized several DOE carbon removal activities, including DAC RD&D activities and a DAC technology prize competition. IIJA fully funded the technology prize at $115 million and provided an additional $3.5 billion to develop four Direct Air Capture Hubs, defined in the act as a "network of direct air capture projects, potential carbon dioxide utilization off-takers, connective carbon dioxide transport infrastructure, subsurface resources, and sequestration infrastructure located within a region."

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 (P.L. 110-343), expanded them in 2018 (P.L. 115-123), and extended them in 2020 (P.L. 116-260). Under current law, eligible projects may receive tax credits up to $50 per metric ton of CO_2. Projects must meet certain requirements such as minimum capture amounts, monitoring procedures, and start-of-construction deadlines. Changes to these requirements have been proposed as part of the FY2022 budget reconciliation process.

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, existing U.S. projects, and historic appropriations for CCUS RD&D are discussed in CRS Report R44902, *Carbon Capture and Sequestration (CCS) in the United States*.

Appropriations for CCUS and DAC are discussed further in CRS In Focus IF11861, *Funding for Carbon Capture and Carbon Removal at DOE*.

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