Federal Energy R&D: Carbon Capture

BY COLIN CUNLIFF | APRIL 2019

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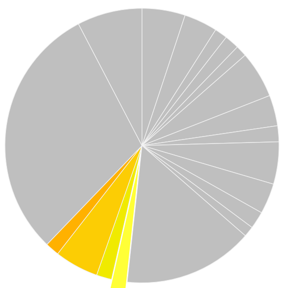
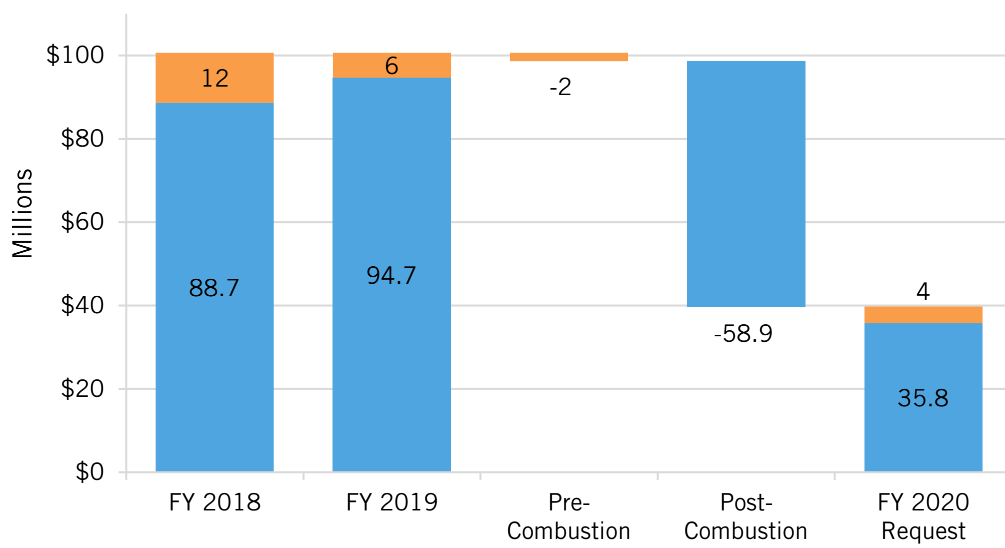


Carbon Capture (yellow)
Other Fossil (yellow)
Energy R&D (light gray)

Carbon capture, utilization, and storage (CCUS) technologies for fossil-fuel power plants have the potential to preserve important options—including coal- and natural gas-fired electricity generation—in a carbon-constrained future. CCUS is also the only option for decarbonizing many industrial processes—such as the production of ethanol, fertilizers, plastics, cement, and steel—for which zero-carbon alternatives do not exist.[1] The recent Intergovernmental Panel on Climate Change (IPCC) special report on 1.5°C of warming found that CCUS technologies play an essential role in nearly all deep decarbonization pathways.[2] DOE's carbon-capture RD&D program focuses on two complementary technologies for coal-fired power plants: pre-combustion systems, in which coal is gasified to allow for the removal of carbon dioxide (CO_2) prior to combustion or use in fuel cells; and post-combustion capture, which removes CO_2 from flue gas after combustion.

Figure 1: The FY 2020 Budget Request Would Cut Carbon Capture R&D by 60 Percent.[3]



What's At Risk

CCUS may be on the cusp of significant new buildouts and cost reductions. DOE's Industrial Carbon Capture and Storage (ICCS) program culminated in the successful launch of CCUS demonstration projects at the Port Arthur fertilizer facility in 2013 and the Archer Daniels Midland ethanol plant in 2017.[4] The world's largest successful post-combustion carbon-capture facility came online at the Petra Nova coal power plant in Texas in 2017.[5] A new pilot-scale natural gas oxy-combustion demonstration began operating at the NET Power facility in Texas in 2018.[6] And in February 2018, Congress expanded and extended the 45Q tax credit to incentivize greater utilization and storage of captured CO_2.[7]

However, continued improvement and cost reductions must occur before CCUS will be viable for full-scale deployment. Even with the 45Q tax credit, current state-of-the-art technologies for capturing and storing carbon emissions are still too expensive to spur widespread deployment in the largest emitting sectors, particularly power plants and cement and steel production.[8] While many of the research needs for carbon capture are crosscutting across all sources, what works for a coal power plant is not directly portable to a natural gas plant or other industrial sources such as cement and steel production plants. Integrating and optimizing carbon capture technologies with other sources faces technical hurdles unique to each source that must be addressed through pilot-scale demonstrations.[9]

DOE has set the ambitious target of reducing the cost of carbon capture to less than $40 per metric ton of CO_2 by 2025—and under $30 per metric ton by 2035.[10] Additionally, DOE has sought to establish international leadership in CCUS technologies through its participation in the Clean Energy Ministerial and Mission Innovation.[11] Reductions in R&D funding, and a shift away from demonstration projects, threaten to delay or even derail current DOE progress toward these targets and cede U.S. leadership in the emerging global CCUS industry.

Carbon Capture R&D Activities

R&D in carbon capture is spread across two activities:

- **Post-Combustion Capture Systems** focuses on separating and capturing CO_2 from flue gas after the fuel has been combusted, and can be used to retrofit existing fossil-fuel power plants. Because CO_2 makes up only 3-4 percent of flue gas from natural gas plants and 12-15 percent of flue gas from coal plants, separation is challenging—and once separated, the pure CO_2 must then be compressed for sequestration.[12] Recent funding has gone to the development of second-generation technologies for these functions, including pilot tests at the National Carbon Capture Center, as well as their integration with advanced power cycles and environmental control technologies for other pollutants.[13]

- **Pre-Combustion Capture Systems** focuses on removing CO_2 from fossil fuels before combustion is complete. Coal can be gasified under high pressure to produce a mixture of hydrogen (H_2) and highly concentrated CO_2, with the former used for energy storage and fuel, and the CO_2 captured and sequestered. Recent R&D has focused on advanced solvents, sorbents, and membranes to lower the cost of CO_2 separation for pre-combustion systems.

Activities in the Carbon Capture program are tightly coupled with R&D in advanced energy systems. Solid oxide fuel cells (SOFCs), gasification systems, oxy-combustion and chemical looping combustion, and direct-fired supercritical CO_2 cycles (i.e., the Allam cycle), are all designed and optimized to integrate with carbon capture technologies.[14]

Key Elements of the FY 2020 Budget Proposal

- **A discontinuation of all large-scale demonstrations, pilot projects, and similar ventures that address technology scale-up and commercialization.** However, demonstration of carbon capture systems at full scale is necessary to establish cost, reliability, and performance characteristics and optimize integration with industrial and power sector carbon sources.

- **A 60-percent reduction in Post-Combustion Capture Systems**, including a shift away from 2nd generation amine capture systems. The budget proposes refocusing on early-stage research and bench-scale development of non-aqueous solvents, membranes, advanced sorbents, and cryogenic processes with the potential to reduce the cost of CO_2 capture.[15]

- **A 33-percent reduction in Pre-Combustion Capture Systems,** including a discontinuation of all large-scale demonstrations and pilot projects. No funding is requested for activities to scale up pre-combustion technologies beyond bench-scale demonstrations.[16]

ENDNOTES

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ACKNOWLEDGMENTS

The author wishes to thank the David M. Hart for providing input to this report.

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