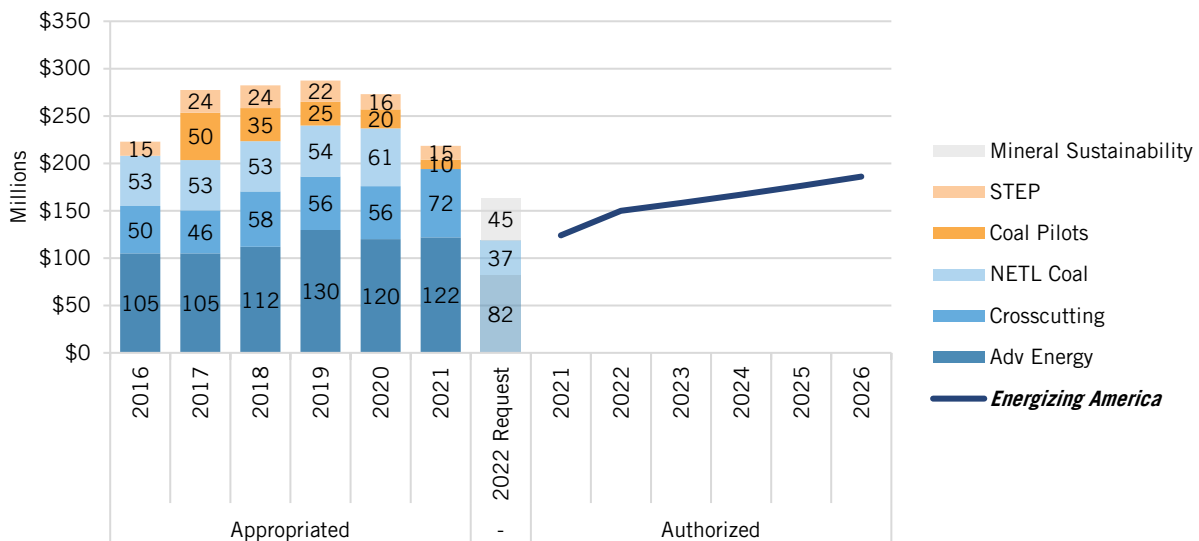


# Federal Energy RD&D: Advanced Coal Energy Systems

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The Department of Energy’s (DOE) advanced coal energy systems research, development, and demonstration (RD&D) program includes several subprograms aimed at improving the efficiency of coal-based power systems, developing advanced technologies such as gasification and fuel-cell systems, improving environmental mitigation of coal power, and enhancing the value of coal and coal byproducts.<sup>1</sup>

**Figure 1: The Energy Act of 2020 did not provide new authorizations for existing advanced coal energy systems research.<sup>2</sup>**



## What’s at Stake

Coal currently accounts for 24 percent of U.S. electricity generation and 60 percent of power-sector carbon emissions.<sup>3</sup> Coal-fired generation is projected to decline through the mid-2020s, as older, uneconomical coal power plants retire. However, coal will likely remain a significant part of the nation’s electricity mix until 2030, unless competitive pressure increases over time.<sup>4</sup> The National Academies of Sciences, Engineering, and Medicine found that achieving net-zero emissions by mid-century will require phasing out unabated coal-fired generation or retrofitting systems to capture 90 percent or more of carbon dioxide (CO<sub>2</sub>) emissions by 2030.<sup>5</sup>

Some Advanced Coal Energy Systems RD&D projects are designed and intended to integrate with carbon capture technologies, which would enable the continued use of coal in low-carbon energy systems. For example, gasification systems combine coal with oxygen and steam under high pressure to produce a hydrogen and CO<sub>2</sub> gas mixture. The CO<sub>2</sub> can be separated prior to combustion, and the remaining hydrogen combusted in a combined-cycle power plant.<sup>6</sup> Similarly, solid oxide fuel cells (SOFCs) convert gasified coal into electricity without combustion, and produce highly concentrated CO<sub>2</sub> streams that enable low-cost carbon capture.<sup>7</sup> Additional

RD&D of SOFCs and gasification systems integrated with carbon capture will be necessary to lower costs and sufficiently improve performance to enable commercial deployment.

In the previous administration, the bulk of funding in the Advanced Coal Energy Systems programs supported the Trump administration's Coal FIRST (Flexible, Innovative, Resilient, Small, Transformative) initiative to improve the economics of coal-fired electricity generation and develop the next generation of high-efficiency coal plants. In February 2020, DOE announced \$64 million in federal funding for research and development (R&D) to develop advanced combustion technologies, supercritical CO<sub>2</sub> systems, and other coal technologies.<sup>8</sup> But without integration with carbon capture, utilization, and storage (CCUS), efficiency improvements alone will not be sufficient to achieve deep emissions reductions from coal-fired power plants.

The Energy Act of 2020 provides the first reauthorization of DOE's Fossil Energy programs in more than a decade. However, the bill does not provide new authorizations for DOE's existing advanced coal energy systems research programs.

Figure 1 shows historical DOE investment in advanced fossil energy systems by subprogram for FY 2016 through 2021, and the FY 2022 budget request. The *Energizing America* report (blue line) recommends a refocusing on carbon-capture-ready technologies (see box 1).

### Box 1: An Innovation Agenda for Advanced Fossil Energy Systems

The *Energizing America* report coauthored by the Information Technology and Information Foundation (ITIF) and Columbia University's Center on Global Energy Policy recommends that DOE and Congress continue to support carbon-capture-ready technologies but does not recommend funding for other fossil-based technologies.<sup>9</sup> Only coal with high-efficiency carbon capture rates (>95 percent) and strong pollution controls is consistent with a net-zero energy system that is fair and equitable. An innovation agenda for deep decarbonization should include support for carbon capture but exclude technologies that are inconsistent with the net-zero goal.

### Advanced Coal Energy Systems Subprograms

Advanced Coal Energy Systems RD&D is spread across five subprograms:<sup>10</sup>

- **Advanced Energy Systems** focuses on improving the efficiency of coal-based power systems, and supports research across seven areas: gasification, which converts coal into synthesis gas, chemicals, hydrogen, and liquid fuels (and complements pre-combustion carbon capture R&D); solid oxide fuel cells, which can convert synthesis gas and other fuels into electricity without combustion or emissions; advanced turbines; advanced sensors and controls; power-generation efficiency; advanced energy materials; and coal processing.
- **Crosscutting Research** serves as a bridge between basic and applied research by targeting the concepts with the greatest potential for transformational breakthroughs. Current research focuses on these primary activities: improved water management in power plant operations; recovery of rare-earth elements as a byproduct of coal production and use; and modeling, simulation, and analysis of environmental and regulatory impacts.

- **Supercritical Transformational Electric Power (STEP)** is a 10-megawatt (MW) pilot-scale demonstration of a Brayton cycle energy conversion system, which uses supercritical CO<sub>2</sub> rather than the traditional steam/water Rankine cycle to convert heat to electricity. Supercritical CO<sub>2</sub> cycles have higher thermal efficiencies and applications for nuclear, gas, and concentrating solar as well as coal power plants.<sup>11</sup>
- **Transformational Coal Pilots** provides funding for the design, construction, and operational costs of two large-scale pilot projects for transformational coal technologies, including pressurized oxygen combustion and chemical looping, and improvements in carbon capture systems.<sup>12</sup>
- **NETL Coal R&D** funds all National Energy Technology Laboratory (NETL) in-house research efforts, including the Fossil Energy Roadmap and the NETL Science & Technology competency assessments.

## ADVANCED COAL ENERGY SYSTEMS

### Key Elements of the FY 2022 Budget Proposal

The budget proposal seeks \$163.5 million for Advanced Coal Energy Systems RD&D activities, a 40 percent reduction from FY 2021 enacted levels. Some highlights include:

- **A 33 percent reduction in the Advanced Energy Systems subprogram**, with a proposed program name change to Advanced Energy and Hydrogen Systems. The program will not fund R&D for fossil fuel-based power generation and will instead support R&D to advance hydrogen-fueled turbines, fuel cells, and carbon capture, utilization, and storage technologies. Funding is reduced for Reversible Solid Oxide Fuel Cells and Transformative Power Generation. Funding for gasification systems would increase by \$29 million to enable R&D in hydrogen production.<sup>13</sup>
- **A new Mineral Sustainability subprogram**, which will include carbon ore processing activities (formerly Advanced Coal Processing within the Advanced Energy Systems subprogram) and critical minerals R&D activities.<sup>14</sup>
- **A 49 percent reduction in the Crosscutting Research and Analysis subprogram**, primarily due to funding elimination for RD&D in fossil combustion. The subprogram will shift its focus to seven activities: 1) sensors, controls, and novel concepts; 2) water management RD&D; 3) simulation-based engineering; 4) energy analysis; 5) university training and research; 6) international activities; and 7) the Energy Storage Grand Challenge.<sup>15</sup>
- **No funding for the Transformational Coal Pilots subprogram.**<sup>16</sup>
- **No funding for Super Critical Transformational Electric Power (STEP) R&D.**<sup>17</sup>
- **No funding for National Energy Technology Laboratory (NETL) Coal R&D.**<sup>18</sup>

### Further Reading

- Varun Sivaram et al., *Energizing America: A Roadmap to Launch a National Energy Innovation Mission* (ITIF and Columbia University SIPA Center on Global Energy Policy, 2020), <http://www2.itif.org/2020-energizing-america.pdf>.

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## **About ITIF**

The Information Technology and Innovation Foundation (ITIF) is an independent, nonprofit, nonpartisan research and educational institute focusing on the intersection of technological innovation and public policy. Recognized by its peers in the think tank community as the global center of excellence for science and technology policy, ITIF's mission is to formulate and promote policy solutions that accelerate innovation and boost productivity to spur growth, opportunity, and progress.

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## ENDNOTES

1. DOE is proposing to restructure its R&D programs within the CCUS and Power Systems account into a new program that “improves the alignment of the budget structure to the research focus areas.” Here, the term “Advanced Coal Energy Systems” refers to the programs in the new budget structure, minus the CCUS programs. DOE, “FY 2021 Congressional Budget Justification,” Volume 3 Part 2, 207–244 (DOE Chief Financial Officer, DOE/CF-0164, February 2020), [https://www.energy.gov/sites/prod/files/2020/02/f72/doe-fy2021-budget-volume-3-part-2\\_2.pdf](https://www.energy.gov/sites/prod/files/2020/02/f72/doe-fy2021-budget-volume-3-part-2_2.pdf).
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9. Varun Sivaram et al, *Energizing America: A Roadmap to Launch a National Energy Innovation Mission* (ITIF and Columbia University Center on Global Energy Policy, 2020), <https://itif.org/publications/2020/09/15/energizing-america-roadmap-launch-national-energy-innovation-mission>.
10. DOE, “FY 2021 Congressional Budget Justification,” Volume 3 Part 2, 207–244.
11. DOE, “DOE Announces \$80 Million Investment to Build Supercritical Carbon Dioxide Pilot Plant Test Facility” (Washington, D.C.: October 17, 2016), <https://www.energy.gov/articles/doe-announces-80-million-investment-build-supercritical-carbon-dioxide-pilot-plant-test>; Southwest Research Institute, “SwRI, GTI, and GE Break Ground on \$119 Million Supercritical CO2 Pilot Power Plant” (October 15, 2018), <https://www.swri.org/press-release/swri-gti-ge-supercritical-CO2-pilot-power-plant>.
12. DOE, “Department of Energy to Invest \$6.5 Million for Large-Scale Pilot Fossil Fuel Projects,” (DOE, February 15, 2018), accessed April 1, 2019, <https://www.energy.gov/articles/department-energy-invest-65-million-large-scale-pilot-fossil-fuel-projects>.
13. DOE, “FY 2022 Congressional Budget Justification” Volume 3.2, (DOE Chief Financial Officer DOE/CF-0174, May 2021), 185, <https://www.energy.gov/sites/default/files/2021-06/doe-fy2022-budget-volume-3.2-v3.pdf>.
14. Ibid, 185-186.
15. Ibid, 178.
16. Ibid, 168.
17. Ibid.
18. Ibid.