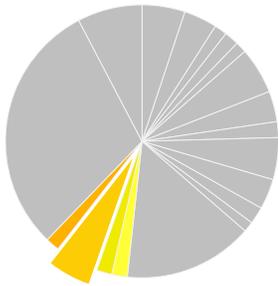




Federal Energy R&D: Advanced Coal Energy Systems

BY COLIN CUNLIFF | APRIL 2019

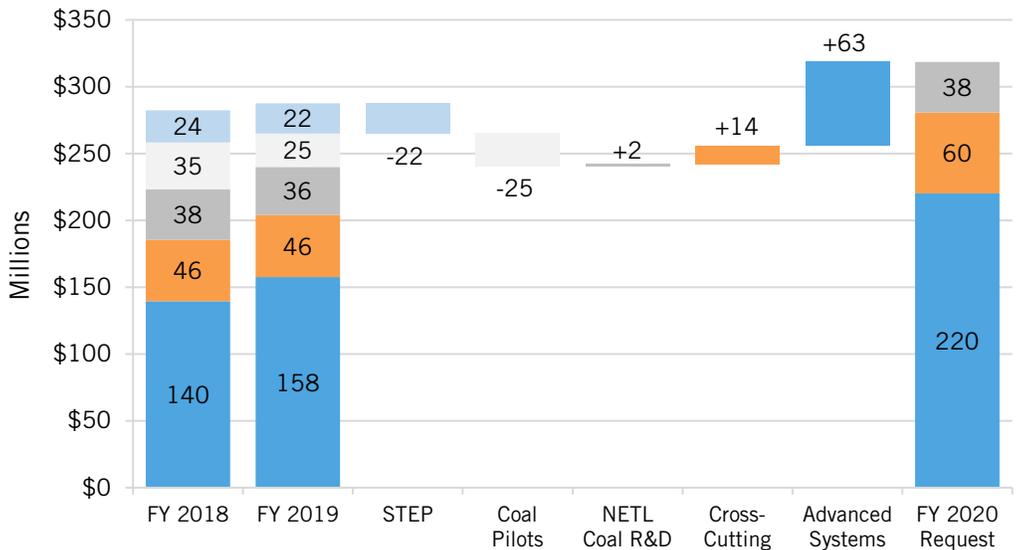
This briefing is part of a series on the U.S. energy budget. See: itif.org/energy-budget.



Adv Coal (orange)
Other Fossil (yellow)
Energy R&D (light gray)

The Department of Energy’s (DOE) Advanced Coal Energy Systems R&D program focuses on 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 by-products.¹

Figure 1: The FY 2020 Budget Request Would Increase Advanced Coal Energy Systems R&D by 11 Percent.²



What's At Stake

Coal currently accounts for 27 percent of U.S. electricity generation and 65 percent of power-sector carbon emissions.³ It is projected to remain an important part of the nation’s energy mix for decades to come.⁴ Many Advanced Coal Energy Systems R&D projects seek to minimize greenhouse gas emissions and other environmental impacts from coal-fired electricity generation, which would enable the continued use of coal in low-carbon energy system. For example, gasification systems combine coal with oxygen and steam under high pressure to produce synthesis gas, which can be used in fuel cells or combined-cycle power plants. Gasification systems are optimized for integration with pre-combustion carbon capture systems. Similarly, solid oxide fuel cells (SOFCs) convert gasified coal into electricity without combustion and with fewer emissions than conventional coal plants.⁵ Additional RD&D is necessary to lower costs and sufficiently improve performance to enable commercial deployment of SOFCs and gasification systems.

The bulk of funding in DOE's Advanced Coal Energy Systems programs supports activities to improve the efficiency of existing coal plants or to design and build new high-efficiency coal plants, which would improve the economics of coal-fired electricity generation. But without integration with carbon capture, utilization, and storage (CCUS) technologies, efficiency improvements alone will not be sufficient to achieve deep emissions reductions from coal-fired power plants.

Advanced Coal Energy Systems Subprograms

Advanced Coal Energy Systems R&D is spread across five subprograms:⁶

- **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.
- **Cross-cutting 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 MW pilot-scale demonstration of a Brayton cycle energy conversion system, which uses supercritical CO₂ rather than the traditional steam/water Rankine cycle to convert heat to electricity. Supercritical CO₂ cycles have higher thermal efficiencies and have applications for nuclear, gas, and concentrating-solar as well as coal power plants.⁷
- **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.⁸
- **NETL Coal R&D** funds all NETL in-house research efforts, including the Fossil Energy Roadmap and the NETL Science & Technology competency assessments.

Key Elements of the FY 2020 Budget Proposal⁹

- **Continues the administration's Coal FIRST (Flexible, Innovative, Resilient, Small, Transformative) initiative to advance new coal power plant designs** that are small (50 to 350 MW), efficient (40 percent or more thermal efficiency), capable of ramping, and have emissions less than or equal to natural gas plants.

- **A 40-percent increase in Advanced Energy Systems**, with \$70 million in new funding for the new Coal FIRST initiative for new first-of-a-kind coal generation technologies, and \$30 million to improve the performance of existing coal plants. Funding for advanced sensors and controls and advanced energy materials would also receive increases. Funding for turbines that can withstand higher temperatures and pressures, gasification systems, and coal processing would be reduced; and solid oxide fuel cell R&D would be cut by 90 percent.
- **A 30-percent increase in Cross-cutting Research**, including increases for rare earth element extraction and separation from coal byproducts; waste-water treatment and other water management R&D; modeling, simulation, and analysis to improve operational efficiency; university training and research; and funding for new intra-agency initiatives in harsh environment materials and advanced energy storage.
- **A discontinuation of funding for the Transformational Coal Pilots program.** Approximately \$15 million in prior year funding will be used to select five Phase II (design) awards in August 2019, and the balance of prior year funding will be used for at least one Phase III (construction/operation) award.
- **A discontinuation of funding for STEP**, as prior year balances have fully funded the pilot STEP project, now under construction in San Antonio, and the administration has not announced any plans follow-on work.
- **A 6-percent boost to NETL Coal R&D** in the areas of systems engineering and analysis, structural materials, and geological and environmental systems.

ENDNOTES

1. DOE is proposing to restructure its R&D programs within the CCS and Power Systems account to a new structure 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 carbon capture, utilization, and storage (CCUS) programs. DOE, “FY 2020 Congressional Budget Justification,” Volume 3 Part 1, 421-459, (DOE Chief Financial Officer, DOE/CF-0152, March 2019), https://www.energy.gov/sites/prod/files/2019/03/f61/doe-fy2020-budget-volume-3-part-1_0.pdf.
2. DOE, “FY 2020 Congressional Budget Justification,” Volume 3 Part 1, 424-425.
3. EIA, “Monthly Energy Review,” Tables 7.2a and 12.6, accessed April 1, 2019, <http://www.eia.gov/mer>.
4. EIA, “Annual Energy Outlook,” Table 1, <http://www.eia.gov/aeo>. Accessed April 1, 2019.
5. National Energy Technology Laboratory (NETL), “Solid Oxide Fuel Cell,” <https://www.netl.doe.gov/coal/fuel-cells>, accessed April 1, 2019.
6. DOE, “FY 2020 Congressional Budget Justification,” 422-459.
7. DOE, “DOE Announces \$80 Million Investment to Build Supercritical Carbon Dioxide Pilot Plant Test Facility,” <https://www.energy.gov/articles/doe-announces-80-million-investment-build-supercritical-carbon-dioxide-pilot-plant-test>, accessed April 1, 2019; Southwest Research Institute, “SwRI, GTI, and

GE Break Ground on \$119 Million Supercritical CO2 Pilot Power Plant,” <https://www.swri.org/press-release/swri-gti-ge-supercritical-CO2-pilot-power-plant>, accessed April 1, 2019.

8. DOE, “Department of Energy to Invest \$6.5 Million for Large-Scale Pilot Fossil Fuel Projects,” (DOE, February 15, 2018), <https://www.energy.gov/articles/department-energy-invest-65-million-large-scale-pilot-fossil-fuel-projects>, accessed April 1, 2019.
9. DOE, “FY 2020 Congressional Budget Justification,” 422-459; DOE, “Energy Department Announces Intent to Fund Research that Advances the Coal Plants of the Future,” (DOE, November 13, 2018), <https://www.energy.gov/fe/articles/energy-department-announces-intent-fund-research-advances-coal-plants-future>, accessed April 1, 2019.

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