



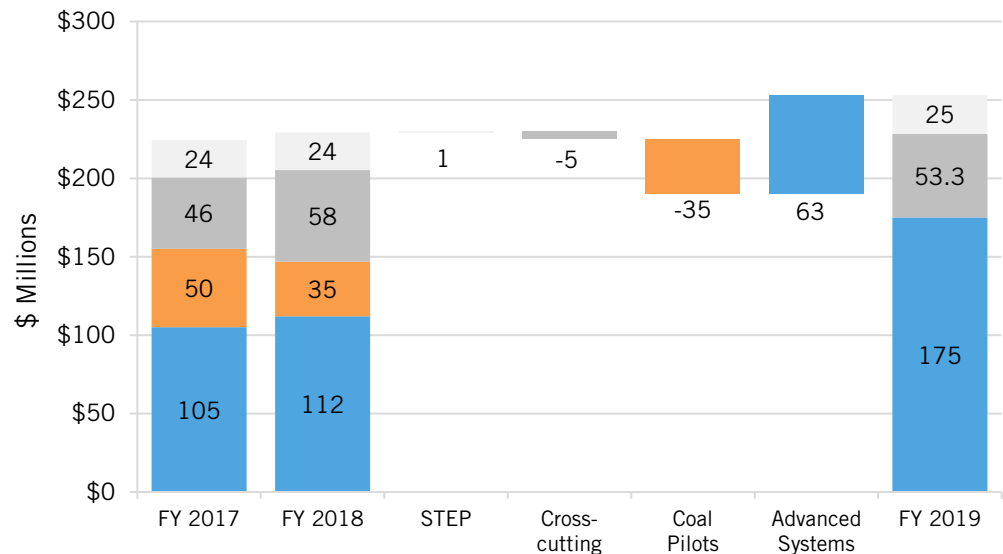
# Federal Energy R&D: Advanced Coal Energy Systems

BY DAVID M. HART AND COLIN CUNLIFF | APRIL 2018

*This briefing is part of a series on the U.S. energy budget. See: [itif.org/energy-budget](http://itif.org/energy-budget).*

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.

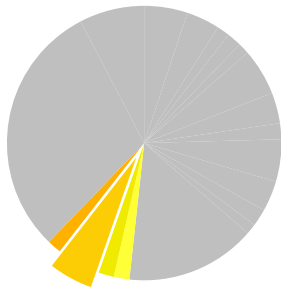
**Figure 1: The FY 2019 Budget Request Would Increase Advanced Coal Energy Systems R&D by 7 Percent**



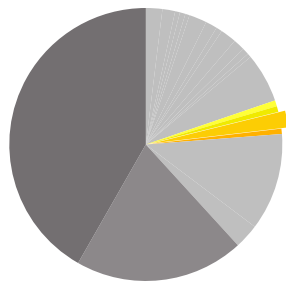
## What's At Risk

Coal currently accounts for 30 percent of U.S. electricity generation and 69 percent of power-sector carbon emissions.<sup>1</sup> It is projected to remain an important part of the nation’s energy mix for decades to come.<sup>2</sup> Coal and other power-generation technologies that convert heat into electricity (including natural gas, nuclear, concentrated solar, and geothermal power systems) require large volumes of water for cooling, accounting for 45 percent of total U.S. water withdrawals—more than all of agriculture.<sup>3</sup> Many Advanced Coal Energy Systems R&D projects seek to maximize the electricity generated from each ton of coal by the existing fleet of power plants while minimizing their water use.

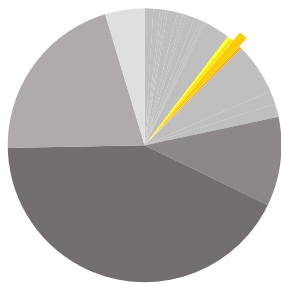
The program also seeks to develop new technologies that would substantially reduce the environmental impacts of coal-based power systems. For example, gasification systems combine coal with oxygen and steam under high pressure to produce synthesis gas, which can be used in fuel cells or combined-cycle power plants. The gasification process also



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



Adv Coal & Energy R&D  
Basic Science R&D  
Defense R&D



Adv Coal & Energy  
Basic Science  
Defense  
Environ Mngmt  
Other DOE

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produces a high-concentration stream of carbon dioxide (CO<sub>2</sub>), which can be captured more easily than in conventional coal plants. The first integrated coal gasification combined-cycle power plant in the United States went into operation at the Kemper facility in Mississippi in October 2016.<sup>4</sup> However, due to cost overruns, the facility switched to natural gas in June 2017, indicating more R&D is needed to bring this technology to maturity.<sup>5</sup> Solid oxide fuel cells (SOFCs) are another promising technology that converts gasified coal into electricity without combustion and with fewer emissions than conventional coal plants. Additional R&D is necessary to lower costs and sufficiently improve performance to enable commercial deployment of SOFCs.

### Advanced Coal Energy Systems Subprograms

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

- **Advanced Energy Systems** focuses on improving the efficiency of coal-based power systems and supports research across six 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; and advanced energy materials.
- **Transformational Coal Pilots** provides funding for the design, construction, and operational costs of two large-scale pilot projects for transformational coal technologies.
- **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 recovery of rare-earth elements from coal and coal by-products; improved water management in power plant operations; and modeling, simulation, and analysis of environmental and regulatory impacts.
- **Supercritical Transformational Electric Power (STEP)** works to develop a Brayton cycle energy conversion system to transform heat energy into electricity using supercritical CO<sub>2</sub>, rather than the traditional steam/water Rankine cycle, and has applications for nuclear, gas, and concentrating-solar as well as coal power plants.

### Key Elements of the FY 2019 Budget Proposal

- **Establishes a goal** of developing two new High-Efficiency (greater than 42 percent), Low-Emission (HELE) small modular coal-plant designs by 2022.
- **A 56-percent increase in Advanced Energy Systems**, including new R&D activities to improve the performance of existing coal plants, develop higher-quality coal, and devise advanced materials for coal-power applications. Funding

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for advanced combustion/gasification systems, turbines that can withstand higher temperatures and pressures, and sensors and controls would receive increases as well. Solid oxide fuel cell R&D would be cut by 90 percent.

- **Elimination of the Transformational Coal Pilots program.**
- **A 9-percent decrease in Cross-cutting Research**, including a decrease in modeling, simulation, and analysis of unexpected plant outages, a doubling of funding for critical minerals and rare-earth-element recovery from coal by-products, flat funding for water management R&D, and additional funding for university training and research programs.
- **A 4-percent increase for STEP funding within the Advanced Coal Energy Systems program.** However, the proposed budget for this collaborative program would decrease funding by 14 percent overall, because of a cut in STEP funding from the office of Nuclear Energy.

## ENDNOTES

1. EIA, “Monthly Energy Review,” Tables 7.1 and 12.6, accessed April 13, 2018, <http://www.eia.gov/mer>.
2. EIA, “Annual Energy Outlook,” Table 1, <http://www.eia.gov/aeo>. Accessed April 13, 2018.
3. DOE, “Quadrennial Energy Review Second Installment: Transforming the Nation’s Electricity System” (Washington, D.C.: DOE, January 2017) 3-57, <https://www.energy.gov/policy/downloads/quadrennial-energy-review-second-installment>.
4. Sonal Patel, “Kemper County IGCC Plant Generates First Syngas-Fueled Power,” *Power Magazine*, October 13, 2016, <http://www.powermag.com/kemper-county-igcc-plant-generates-first-syngas-fueled-power/>.
5. DOE website, “Southern Company – Kemper County, Mississippi,” accessed April 15, 2018, <https://www.energy.gov/fe/southern-company-kemper-county-mississippi>.

## ABOUT THE AUTHORS

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