



Changes in the U.S. electricity industry are forcing a paradigm shift in how the Nation's generating assets operate. Traditionally, coal-fired power plants operated continuously to meet an established minimum level of demand and were not designed for rapid changes in power output. Today, these coal-fired power plants are increasingly relied upon to supplement electricity from intermittent renewable sources, offset variable natural gas demand and supply, and deliver critical ancillary services to the grid.

Flexible, Innovative, Resilient, Small, Transformative

The U.S. Department of Energy's (DOE) Office of Fossil Energy (FE) is funding **Coal FIRST** (Flexible, Innovative, Resilient, Small, Transformative), a research and development (R&D) program to advance first-of-a-kind coal generation technologies to provide secure, stable, and reliable power.

The Coal FIRST program will help develop coal-fired power plants that are:

- **Flexible:** Quick to adjust to the changing needs of the grid.
- **Innovative:** Cleaner, more agile, and more efficient through cutting-edge technology.
- **Resilient:** Able to recover rapidly from severe weather and other events.
- **Small:** Compact relative to today's conventional utility-scale coal plants.
- **Transformative:** Fundamentally re-designed to change how coal technologies are manufactured.

The Future Coal Fleet

The need for considerable dispatchable generation, critical ancillary services, and grid reliability—combined with potentially higher future natural gas prices and energy security concerns, such as onsite fuel availability during extreme weather events—creates the opportunity for advanced coal-fired generation in domestic and international markets.

Deploying new coal plants will require a different way of thinking. To that end, DOE envisions that the future coal fleet may be based on electricity generating units possessing the following traits:

- High overall plant efficiency (40%+ high heating value or higher at full load over most of the generation range).
- Small, high-quality, low-cost units (50 MW to 350 MW) that minimize field construction time.
- Near-zero emissions (designs/retrofits that emit < the CO₂ of natural gas technology).
- Ramp rates and minimum loads compatible with 2050 estimates of renewable energy integration.
- Integration with thermal or other energy storage to mitigate inefficiencies and equipment damage.
- Minimized water consumption.
- Accelerated design, construction, and commissioning schedules.
- Enhanced maintenance features, including advanced monitoring and diagnostics to reduce downtime.
- Integration with coal upgrading or other plant value streams (e.g., co-production).
- Capable of natural gas co-firing.



Main Activity Areas

Design of a Power Plant of the Future

As Phase I of a 2018 request for proposal, the Coal FIRST program is now evaluating 13 responses of concepts listed below for coal-based power plants of the future:

1. Small-scale flexible AUSC power plant, Electric Power Research Institute
2. Coal-fired Allam cycle, 8 Rivers Capital, LLC
3. All steam gasification design for integration with coal Allam cycle, Wormser Energy Solutions
4. USC coal boiler downstream of NG turbine, Barr Engineering Co.
5. Direct injection carbon engine and gas turbine compound-reheat combined cycle, Nexant, Inc.
6. Modular air-fired pressurized coal combustion, The Washington University
7. ASG designed for, and integrated with, IGCC polygeneration, Wormser Energy Solutions
8. PFBC for indirect sCO₂ cycle, Echogen Power Systems (DE)
9. PFBC for modular coal power, CONSOL
10. Gasification-based polygen with bottoming cycle, Allegheny Science & Technology
11. Oxygen-blown gasification with CL and H₂ turbine/FC, Barr Engineering Co.
12. Modified HECA CCSI study evaluating recent technology developments including IGFC, Hydrogen Energy California, LLC
13. Pressurized oxygen blown fast-circulating fluidized bed, Constantem Technologies LLC

In Phase II, up to six concepts will be selected for preliminary front-end engineering design (FEED); in the third phase, two designs will complete FEED prior to the pilot plant construction.

Component R&D

DOE released two funding opportunity announcements (FOAs) for cost-shared R&D projects to ensure that the designed power plant can be built. The two primary focus areas of these projects include:

- Steam turbines that can be integrated into a 50 MW to 350 MW advanced coal plant design.
- Critical components and advanced approaches (e.g., manufacturing, fabrication, advanced design) to support a future coal plant.

The awards will be made in the 4th quarter of 2019.

Existing Plant Efficiency Improvement Demonstrations

To ensure that efficiency improvements can be incorporated into the Power Plant of the Future, DOE issued FOA 1989 in December 2018 to support R&D on various areas of existing coal power plants. The award is scheduled for 4th quarter of 2019, and the results of these projects will be incorporated into the Power Plant of the Future FEED studies.

For further information, please contact:

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