Transformative Power Generation

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November 2020
Coal Power Generation Challenged by Changing Power Markets

• **Current Electricity Landscape**
  • Renewable energy will continue to increase in market share
  • Changing market conditions require flexible power plants

• **DOE-FE Approach**
  • Ensure coal-fired generation is clean, efficient, and cost competitive
  • Capitalize on the inherent stored energy and dispatchability of coal
  • Develop solutions that are not one size fits all – Based on regional market needs
Transformative Power Generation Program

R&D Focus Areas

- Existing Plants
- Coal FIRST
- Advanced Combustion
Program Budget History

<table>
<thead>
<tr>
<th></th>
<th>FY 18 Enacted</th>
<th>FY 19 Enacted</th>
<th>FY 20 Enacted</th>
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<tbody>
<tr>
<td>$26</td>
<td>$48.7</td>
<td>$40.5</td>
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Program Funding ($M)

![Bar chart showing program funding history for FY 18, FY 19, and FY 20. The chart indicates a significant increase from FY 18 to FY 19, followed by a slight decrease in FY 20.]
Coal FIRST

Existing Plants

Coal FIRST

Advanced Combustion

Mid-Term
Implement in 4-12 years
Coal FIRST: Mission, Need, and Goal

- Keep coal power generation in mix beyond 2050
- Capability for net negative carbon dioxide emissions is key
- Business case to enable wide-scale replication within markets
Technology Development Schedule: Coal FIRST

- Flexible Ultra Supercritical (USC) Coal-Fired Power Plant
- Hybrid Natural Gas Turbine / USC Coal Boiler Power Plant
- Pressurized Fluidized Bed Combustor with Supercritical Steam Cycle Power Plant
- Indirect Supercritical Carbon Dioxide Power Plant System
- Direct-fired Supercritical Carbon Dioxide Power Plant System
- Gasification Based Poly-generation Power Plant System
- Coal-Fired Direct Injection Combustion Engine & Gas Turbine Compound Reheat Combined Cycle Power Plant System
- Modular Staged Pressurized Oxy-combustion Power Plant System
## Implementation Began FY19

### Coal FIRST: Coal Plant of the Future

<table>
<thead>
<tr>
<th>Title</th>
<th>Objective</th>
<th>Funding (DOE/Total)</th>
<th>Issued</th>
<th>Closed</th>
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<tbody>
<tr>
<td><strong>RFP No. 89243319RFE000015</strong></td>
<td><strong>“Coal-Based Power Plants of the Future”</strong></td>
<td>$9.8M/$9.8M</td>
<td>Nov 12, 2018</td>
<td>Jan 25, 2019</td>
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<td>Develop the program’s conceptual design with an option to conduct preliminary front-end engineering design (Pre-FEED) studies.</td>
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<td><strong>FOA-2057</strong></td>
<td><strong>“Critical Components for Coal FIRST Power Plants of the Future”</strong></td>
<td>$37M/$47M</td>
<td>Feb 7, 2020</td>
<td>Apr 13, 2020</td>
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<td>Development of critical components that will support potential designs for coal-based power plants of the future.</td>
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<td><strong>FOA-0002180</strong></td>
<td><strong>“Design Development and FEED Studies for Coal FIRST Systems”</strong></td>
<td>Up to $81M/$101.25M</td>
<td>DRAFT: May 18, 2020</td>
<td>FINAL: July 17, 2020</td>
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<tr>
<td>To make available up to ~$81 million for cost-shared R&amp;D projects focused on performing Front End Engineering Design (FEED) studies for the Coal FIRST plant with allowances for limited design development.</td>
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</table>
Testing and Model-Based Optimization of Coal-Fired Primary Heater Design for Indirect Supercritical CO₂ Power Cycles

A High-Efficiency, Modular Pre-Combustion Capture System for Coal FIRST Poly-generation Process

Development of Critical Components for the Modular Staged Pressurized Oxy-combustion Power Plant

High-Temperature Seals for Supercritical CO₂ Turbines

Advanced Ceramic Membranes/Modules for Ultra-Efficient H₂ Production/CO₂ Capture for Coal-Based Poly-generation Plants

Zero Emission Syngas Combustor Test

Development of Coal Syngas Oxy-Combustion Turbine for Use in Advanced sCO₂ Power Cycles
Coal FIRST FEED FOA-2180 Selections

Front-End Engineering Design Study for Hybrid Gas Turbine and USC Coal Boiler Concept (HGCC) Plant with Post Combustion Carbon Capture and Energy Storage System at City, Water, Light and Power Plant

Gasification of Coal and Biomass: The Route to Net-Negative-Carbon Power and Hydrogen

Design Development and System Integration Design Study for an Advanced Pressurized Fluidized Bed Combustion Power Plant with Carbon Capture

Wabash Hydrogen Negative Emissions Technology Demonstration
Accomplishments & Next Steps
Coal FIRST: Coal Plant of the Future

Accomplishments
✓ Stakeholder input (Request for Information)
✓ 13 Concept Studies performed
✓ Seven Pre-FEED Studies completed in April/May 2020
  Pre-FEED Study deliverables posted here:
  https://netl.doe.gov/coal/tpg/coalfirst/concept-reports
✓ FOA-0002057 - Selected 7 R&D projects for components of promising systems of future coal plants
  Announcement:
  https://www.energy.gov/fe/articles/foa-2057-project-selections
✓ FOA-0002180 – Selected 4 projects for Design Development and FEED Studies
  Announcement:
  https://netl.doe.gov/node/10255

Next Steps
• Award FEED studies
  Fall/Winter 2020
Improvements for Existing Plants

Near-Term
Implement in 2-10 years
Coal Fleet R&D – Challenges and Focus

Baseload coal plants being deployed as load-following units

Performance and equipment degradation accelerated

Assist plants with improving:
- Increased flexibility
- Improved reliability
- Optimized efficiency
Existing Plants Projects

ORGANIZATION TYPE
(# includes partners)
- Service Provider (26)
- Equipment Manufacturer (15)
- Coal Company (1)
- Research Institute (4)
- University (18)
- National Laboratory (3)
- Utilities (24)
Technologies in Development

- Advanced Sensors (incl. temperature, corrosion, wireless, real-time, combustible gases, ash deposition)
- Reduced Low-load Technology
- Online Coal Analyzer
- Advanced Ash Management
- Dynamic Plant Control Systems for Improved Transient Operation
- Coatings for Reliability and Efficiency
- Condition-based Monitoring Systems
- Energy Storage
- Dynamic Plant Models
- Online System Identification
- Energy Systems & Market Analysis
Accomplishments

Improvements for Existing Plants

✓ Conducting field testing at over 21 power plants with 24 utilities
✓ Installed extended low-load boiler system
✓ Tested online coal tracker with combustion system performance prediction
✓ Tested wireless temperature and corrosion sensors
✓ Tested ultrasonic sensors for real-time temperature profiles
✓ Detected and diagnosed pre-mature equipment failure using machine learning
✓ Tested improved condenser coating technology
Transformative Power Generation
Advanced Combustion R&D

Long-Term
Implement by 2030-2035
Advanced Combustion Technologies

**Washington University in St. Louis**
Application: *Staged Pressurized Oxy-combustion*

**Southwest Research Institute**
Application: *Flameless Pressurized Oxy-combustion*

**NETL Research and Innovation Center**
Application: *Chemical Looping Combustion*

100 kW Prototype Staged Pressurized Oxy-combustor

Traditional Combustion with Flame Front  Flameless Pressurized Combustion

Traditional Combustor Products: Particulate  FPO Combustor Products: Near-zero carbon, neutral slag

NETL’s High Temperature Environmental Confocal Scanning Laser Microscope
Takeaways

• Coal-fired plants must be more flexible, reliable, and efficient
• Program focuses on existing and new plants
• Lab and field testing of impactful technologies underway
• All projects have industry involvement

Stakeholder involvement essential for transition of technologies to industry
Questions?

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https://netl.doe.gov/coal/tpg

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