Research and Development, Federal and State Partnership with Industry

Identifying Synergies Among Federal and State Research and Development Agendas for Advanced Coal Technology including CCUS and Forecasting Future R&D Programs

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Advanced Fossil Technology Systems

Western States Coal Strategies Forum | November 2019 | Moab, Utah
Discover and develop advanced coal technologies that ensure America’s access to resilient, affordable, reliable, and near-zero emitting coal energy resources.

**Coal R&D Budget Priorities**

- Implementing the Coal FIRST (Flexible, Integrated, Resilient, Small, Transformative) initiative: R&D on first-of-a-kind small-scale modular coal plants of the future, which are highly efficient and flexible, with near-zero emissions
- Improving the performance, reliability, and efficiency of the existing coal-fired fleet
- Reducing the cost and risk of carbon capture for commercial deployment
- Creating new market opportunities for coal

<table>
<thead>
<tr>
<th>CCS and Power Systems ($ in thousands)</th>
<th>FY 2019 Enacted</th>
<th>FY 2020 House</th>
<th>FY 2020 Senate</th>
<th>Future Plants</th>
<th>Existing Plants</th>
<th>Cost of Capture</th>
<th>New Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Capture</td>
<td>100,671</td>
<td>125,000</td>
<td>113,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Carbon Storage</td>
<td>98,096</td>
<td>102,000</td>
<td>103,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td>Advanced Energy Systems</td>
<td>129,683</td>
<td>107,000</td>
<td>139,000</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Crosscutting Research*</td>
<td>56,350</td>
<td>65,255</td>
<td>64,300</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Rare Earth Elements*</td>
<td>18,000</td>
<td>23,000</td>
<td>25,000</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
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<tr>
<td>STEP (Supercritical CO2)</td>
<td>22,430</td>
<td>24,000</td>
<td>14,000</td>
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<td></td>
<td>✓</td>
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</tr>
<tr>
<td>Transformational Coal Pilots</td>
<td>25,000</td>
<td>20,000</td>
<td>17,000</td>
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<td></td>
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<tr>
<td>NETL Coal R&amp;D*</td>
<td>36,000</td>
<td>38,000</td>
<td>42,000</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>TOTAL CCS &amp; Power Systems</td>
<td>486,230</td>
<td>504,255</td>
<td>517,300</td>
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</tbody>
</table>
## COAL R&D OVERVIEW

### Advancing R&D for the Existing Coal Fleet and Plants of the Future

#### Creating New Markets for Coal

**Advanced Energy Systems**
- Efficiency improvements for new and existing units
  - Advanced energy materials
  - Advanced gasification
  - Solid oxide fuel cells
  - Advanced coal processing
  - Advanced turbines
  - Advanced combustion
  - Sensors and controls

**Crosscutting Research**
- Crosscutting technology development program
  - Power generation efficiency
  - Supercritical transformational electric power
  - Critical minerals
  - Coal utilization science
  - Transformational coal pilots
  - University research
  - SBIR/STTR*
  - Technology Commercialization Fund (TCF)*

### CO₂ Capture and Utilization

**Reducing the cost of CO₂ capture for new and existing units**
- Post-combustion capture
- Pre-combustion capture
- New pathways to utilize captured CO₂

**CO₂ Storage**
- Safely and permanently storing CO₂
  - Safe use and permanent storage of CO₂ from power generation and industry
  - Minimizing subsurface risks (coordinated with other subsurface offices, e.g., Office of Oil and Natural Gas)
  - CO₂ infrastructure analysis

### Note: Programmatic not necessarily budgetary groupings
*SBIR/STTR and TCF are managed under the Crosscutting Program but funded by all R&D programs*
FY 2020 COAL R&D PRIORITIES

<table>
<thead>
<tr>
<th>Advanced Energy Systems</th>
<th>Crosscutting</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Coal FIRST FEED &amp; Components</td>
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</tr>
<tr>
<td>• Advanced Turbines (Steam, Pressure Gain)</td>
<td>• Pilots for REEs/CM and advanced products</td>
</tr>
<tr>
<td>• Coal recovery and processing</td>
<td>• Energy storage</td>
</tr>
<tr>
<td>• Coal FIRST FEED</td>
<td>• Supercritical CO2 power</td>
</tr>
<tr>
<td>• Scaling Capture Technology</td>
<td>• Advanced computational</td>
</tr>
<tr>
<td>• National Carbon Capture Center</td>
<td>• CarbonSAFE</td>
</tr>
<tr>
<td>• Direct Air and Industrial Capture</td>
<td>• Regional Initiative to Accelerate CCUS</td>
</tr>
<tr>
<td>• Utilization materials/ process intensification</td>
<td>• Artificial Intelligence &amp; Visualization for the subsurface</td>
</tr>
</tbody>
</table>

Carbon Capture & Utilization

Carbon Storage
2020 DOE COAL R&D STAKEHOLDER WORKSHOPS

- **Western Coal Strategies Workshop**
  
  *Moab, Utah*

- **Rare Earth Element and Critical Mineral Production from Domestic Coal-Based Resources**
  
  *October 31, 2019 - Golden, CO*
  *December 11, 2019 – Washington, DC*

- **Coal Extraction, Processing, and Conversion to Advanced Products**
  
  *February – Pittsburgh, PA*

- **Energy Storage from the Fossil Fleet**
  
  *February - Pittsburgh, PA*

- **CCUS and Markets Roundtables - 2020**
17 of 22 states leading R&D projects
5 remaining states partners in R&D

198 Active R&D projects
- Over $1,300M total value,
- >$800M DOE investment
- Across all R&D pillars
- Industry, Academia, National Laboratories and other R&D institutions

>60% of the Coal Produced in the US
PARTNERING WITH DOE COAL R&D PROGRAM

FE (HQ and NETL) Procurement
• Funding opportunity announcement
• Contracting
• University Partnerships (NETL)
• Unsolicited Proposals

Leverage Existing Opportunities
• National Laboratories
• International Agreements
• Technical Assistance
• Regional Initiatives

https://www.netl.doe.gov/
Thank You