• **Power Generation in the US and throughout the world**
  • Renewable Energy will continue to increase in market share
  • Coal will continue to be vital in providing low cost reliable for the future

• **We are committed to developing technologies**
  • Creating more nimble coal-fired generation facilities
  • Ensuring that coal-fired generation is the clean, efficient, and cost competitive
Coal Plants Challenged by Changing Power Markets

• Coal-fired power plants designed for baseload are not being deployed as originally intended or designed
  ➢ Equipment and performance degradation is accelerated
• Changing market conditions require flexible power plants
• Cost and reliability must be improved
Transformative Power Generation

KEY TECHNOLOGIES

- Improvements for Existing Coal Plants (Near-Term – Implement in 3-10 years)
- Coal FIRST – Coal Plant of the Future (Mid-Term – Implement in 5-12 years)
- Advanced Combustion (Long-Term – Implement by 2030-2035)

RESEARCH FOCUS

- Efficiency Improvements
- Reliability Improvements
- Operational Flexibility
- Advancements in State-of-the-art Boilers
- Chemical Looping Combustion
- PFBC/Staged Oxy-Combustion
- Flameless Oxy-Combustion

Near-term Technologies

Transformational Technologies
Transformative Power Generation

KEY TECHNOLOGIES

- Improvements for Existing Coal Plants (Near-Term – Implement in 3-10 years)
- Coal FIRST – Coal Plant of the Future (Mid-Term – Implement in 5-12 years)

RESEARCH FOCUS

- Efficiency Improvements
- Reliability Improvements
- Operational Flexibility
- Advancements in State-of-the-art Boilers

Focus for this Annual Project Review Meeting
GOAL: Develop the coal plant of the future to provide secure, stable, and reliable power.

R&D will underpin coal-fired power plants that are:

• capable of **flexible** operations to meet the needs of the grid;
• use **innovative** and cutting-edge components that improve efficiency and reduce emissions;
• provide **resilient** power to Americans;
• are **small** compared to today’s conventional utility-scale coal plants;
• and will **transform** how coal plant technologies are designed and manufactured.
Improvements for Existing Coal Plants R&D

• Efficiency Improvements
  • Improve heat rates under all conditions
  • Improve heat rate during transient and low-load operation

• Reliability Improvements
  • Reduce forced outages
  • Reduce maintenance cost through predictive monitoring

• Operational Flexibility
  • Improve demand response
  • Lower minimum load
On-Line System Identification

Application: Data Analytics for Coal-fired Plants for Continuous Controller Characterization

- approach to optimize control
- improve efficiency and economics
- improve control during load following
- detect equipment deterioration

Boiler Modeling

Application: Reduced Order Model Development based on Validated CFD Data

- CFD – Based Input Data
- Hidden Neurons
- Output ROM
- ROM’s in the hands of plant operators and managers

On-line SI transfer function @ t=1200s

Controller Output

Process

Fuel Valve Command

Turbine speed from online SI

-0.06276z+0.0321

-0.3074z+0.3166

Accelerated CFD Models

Artificial Neural Network
Stakeholder Outreach - Existing Plants

**RFI**

- **TA1:** Technologies for Efficiency Improvements at Full- and/or Part-Load Operations
- **TA2:** Technologies for Improvements to EGU Reliability, Availability, and Maintainability (RAM)
- **TA3:** Technologies for Improved Operational Flexibility

**FOA 1989**

- **AOI 1:** Sensors, Diagnostics, and Controls to Improve Prediction, Performance, & Reliability
  - **Subtopic A:** High Fidelity Field Testing
  - **Subtopic B:** Relevant Environment Testing
- **AOI 2:** Power Plant Component Improvement
  - **Subtopic A:** High Fidelity Field Testing
  - **Subtopic B:** Relevant Environment Testing
- **AOI 3:** Data Analytics Driven Controls

- Total Funding: $38M; DOE Funding: $34M (Transformative Power Gen), $4M (Cross-cutting)
- 12-20 project awards expected
- Closed February 28, 2019
Takeaways - Transformative Power

• 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
Transformative Power Generation Contacts

https://www.netl.doe.gov/node/6101

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DOE’s Coal Beneficiation R&D Program

John Rockey – Technology Manager

April 9, 2019
Why Coal Beneficiation?

• Annual coal consumption has gone from about 1.2 billion tons to 700 million and could fall to 400 million by 2030

• New coal-fired power plant builds in the U.S. are unlikely over the next 10 years

• Coal has exciting opportunities to expand use in both traditional markets and in new applications
Coal Beneficiation R&D Areas

Coal Beneficiation has three primary R&D areas:

- Coal to Carbon Products
- Feedstock Upgrading
- Coal Properties Database
Expanding the Coal Value Chain

Coal Beneficiation Program
- New processes to maximize coal’s value as a feedstock
- New technologies for value-added products from coal

<table>
<thead>
<tr>
<th>HIGH-VALUE PRODUCTS</th>
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<tbody>
<tr>
<td>CARBON FIBERS</td>
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<tr>
<td>CRITICAL MINERALS</td>
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<tr>
<td>COOKING PROCESS BY-PRODUCTS</td>
</tr>
<tr>
<td>STRUCTURAL &amp; BUILDING MATERIALS</td>
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</tbody>
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ADDITIONAL PROCESSING & MANUFACTURING

- Carbon Nanomaterials
- Plastic Composites
- Energy Storage Materials
- 3D Printing Materials

COAL MINE → COAL PREP PLANT → COOKING PROCESS → STEEL MILL

- Steel
- Fuel
- Chemicals/Consumer Products
- Electricity

SYNGAS PRODUCTION/LIQUEFACTION → COAL POWER PLANTS
Coal Beneficiation Projects

NETL RIC PROJECTS

**Coal-Based Carbon Materials Manufacturing**
National Energy Technology Laboratory Research and Innovation Center – Pittsburgh, PA, Morgantown WV, Albany, OR
TOTAL: $1,150,000 • DOE SHARE: $1,150,000

**Converting Coal into Carbon Nanomaterials and Composites**
Ramaco Carbon – Sheridan, WY
Public-private partnership

**Transforming Coal into High-Value Products**
Russell County Industrial Development Authority and Virginia Carbonite – Russell Co, VA
Public-private partnership

**Technical Economic Analysis of the U.S. Value-Added Coal Product Industry**
Oak Ridge National Laboratory – Oak Ridge, TN
TOTAL: $300,000 • DOE SHARE: $300,000

**The Novel Charfuel® Coal Refining Process TPD Pilot Plant Project for Co-Producing an Upgraded Coal Product and Commercially Valuable Co-Products**
CarbonFuels, LLC – Denver, CO
TOTAL: $3,180,519 • DOE SHARE: $2,000,000

**U.S. Coal to Conductive Inks**
Minus 100, LLC – Clarks Summit, PA
TOTAL: $224,813 • DOE SHARE: $224,813

**Silicon Carbide (SiC) Foam for Molten Salt Containment in CSP-GEN3 Systems**
Touchstone Research Laboratory Ltd. – Triadelphia, WV
TOTAL: $225,000 • DOE SHARE: $225,000

**Pilot-Scale Testing of the Hydrophobic-Hydrophilic Separation Process to Produce Value-Added Products from Waste Coal**
The Minerals Refining Company – Richmond, VA
TOTAL: $2,500,000 • DOE SHARE: $2,000,000

**Efficient Process for the Production of High Conductivity, Carbon-Rich Materials from Coal**
Physical Sciences, Inc. – Andover, MA
TOTAL: $224,985 • DOE SHARE: $224,985

**Innovative Process for the Production of High Conductivity, Carbon-Rich Materials from Coal**
Russell County Industrial Development Authority and Virginia Carbonite – Russell Co, VA
Public-private partnership
Takeaways - Coal Beneficiation

- Exciting opportunities exist to expand the coal value chain
- New program - less than a year old
- Lab scale through pilot scale projects getting underway
- All projects have industry involvement

Stakeholder involvement essential for transition of technologies to industry
Coal Beneficiation R&D Program Contacts

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https://www.netl.doe.gov/Coal_Beneficiation