High Performance Materials

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Program Overview
Annual Project Review Meeting
August 25, 2020
Diverse Portfolio of Programs

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Crosscutting Technology Research
Fossil Energy Materials Value Chain
National program strengthening a $16.5B domestic value chain employing >43,000

Geographic Distribution of HPM Value Chain Employment
Source: Bureau of Labor Statistics, Census Bureau

Fossil Energy Plant

Component: $10.7B – 24,100 jobs

Finishing: $2.0B – 11,700 jobs

Primary shaping: $2.5B – 6,600 jobs

Refining, alloying: $1.3B – 1,200 jobs

Mining
$7 Billion market in 2023

Strong regional footprint

Support employment and economy

Advanced manufacturing

Workforce critical
Electricity Generation
Fossil fuels in future as renewables double

Electricity generation
billion kilowatthours

2019

history projections

2020 2030 2040 2050

Natural Gas
Renewables
Nuclear
Coal

EIA AEO2020 Reference case – www.eia.gov/aeo
Key Fossil Generators In Today’s Fleet
NGCC and PC plants experiencing cycling

Natural Gas Combined Cycle (NGCC)

Common components
Boiler – Steam turbine – Generator

Pulverized Coal (PC) Power Plant

2. https://www.climatetechwiki.org/technology/sup_crit_coal
The Hydrogen Economy

H₂ Generation

- **ELECTRICITY GENERATION**
  - Alkaline | PEM | SO

- **ELECTROLYSIS**
  - Alkaline | PEM | SO

- **NATURAL GAS**
  - SMR | POX | ATR | Pyrolysis

- **COAL | HYDROCARBONS | BIOMASS**
  - Pyrolysis | Gasification

- **THERMOCHEMICAL CONVERSION**
  - CH₃OH | NH₃ | CH₄

- **Metal Hydrides**

- **CO₂ from carbon capture**

- **O₂ from ASU**

- **N₂ from ASU**

H₂ Storage

- **LIQUID**
  - **UNDERGROUND**
    - Salt Caverns | Depleted Oil/Gas Reservoirs

- **PRESSURE VESSELS**

- **ADSORPTION**

H₂ End Use

- **TRANSPORTATION**
  - Synthetic Fuels
  - Hydrogen Vehicles

- **INDUSTRIAL APPLICATIONS**
  - NH₃ | Metals Refining | Other

- **H₂/NATURAL GAS INFRASTRUCTURE**

- **POWER GENERATION**
  - NH₃/H₂ Turbines
  - NH₃/H₂ Reciprocating Engines
  - Fuel Cells (Alkaline, PEM, SO)

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Program Mission & Implementation

Mission

• Produce high performance materials suitable for extreme environments found in fossil power generation to support existing and new plants.
• Encourage change and stimulate innovation in the high performance materials value chain to spur US competitiveness.

Meeting challenging end-user objectives:
• Flexible Operations
• Increased Efficiency
• Reduced Costs
• Intelligent Asset Management

With diverse technical approaches

- Computational material design
- Advanced structural materials
- Advanced manufacturing
Fossil Power Plant Challenges
Addressing existing and future challenges in efficiency, flexibility, and reliability.

**Market Segments**

<table>
<thead>
<tr>
<th>Existing Fleet</th>
<th>Next Generation Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>AUSC</td>
</tr>
<tr>
<td>Gas</td>
<td>Coal SCO₂</td>
</tr>
<tr>
<td></td>
<td>Gasification</td>
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<tr>
<td></td>
<td>Next Gen Gas</td>
</tr>
<tr>
<td></td>
<td>Gas SCO₂</td>
</tr>
</tbody>
</table>

**Technical Challenge Areas**

- Flexible Operation and Performance Optimization
- Asset Utilization
- Condition Based Management
- Performance Improvement
  - Cybersecurity
  - Water use optimization
  - Emissions control
### Strategic Research Thrusts

Recent spending addresses pressing challenges while aligning with broader technology trends

#### MARKET SEGMENTS

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<tr>
<th><strong>Existing Fleet</strong></th>
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<tr>
<td><strong>Objectives</strong></td>
<td>Maintain cost competitiveness of existing assets</td>
</tr>
<tr>
<td><strong>Barriers</strong></td>
<td>Aging infrastructure; Unpredictable outages; Costly repair</td>
</tr>
<tr>
<td><strong>Solutions</strong></td>
<td>Component and Materials Life Prediction; Advanced Manufacturing and Repair Processes</td>
</tr>
</tbody>
</table>
Technology Opportunities

The portfolio develops solutions that directly impact flexible operation and asset life extension.

- **Component and Materials Life Prediction**
- **High temperature/high performing alloys**
- **Advanced Manufacturing and Repair Processes**
- **Computational tools for alloy & process development**
- **Solving Critical Materials Challenges**

- **Materials and Process Modeling**
- **Validation with Plant Data**
- **Welding**
- **3-D Printing**
- **Coating**

- **Alloy Development**
- **Manufacturing Trials**
- **Code Cases**
- **Multi-scale Materials Modeling**
- **Data Analytics**
Investment in materials has broad opportunities to deliver impacts

Active portfolio allocation:

$32.6M (21 projects) to improve short- and long-term profitability

$53.7M (25 projects) to assess equipment health and extend useful life
Technology Development Schedule
High-Performance Materials

2015
- Develop 760C capable materials (ComTest)
- SCO₂ durability research
- Advanced Manufacturing, Welding, Joining
- Existing fleet Materials Failure R&D
- Materials Discovery (XMAT)
- Reduce Manufacturing Cost, improve cycling

2020
- AUSC ready
- Durability shown
- Large Area
- Faster, Better Repair
- Damage Mitigation
- Better Stainless Steel

2025
- Enable AUSC Plants
- Enable SCO₂ Power Cycles
- Address Existing Fleet Materials Issues
- Reduce Alloy & Component Costs

2030
- 2015
- 2020
- 2025
- 2030
- Technology Development Schedule
- High-Performance Materials
- Enable AUSC Plants
- Enable SCO₂ Power Cycles
- Address Existing Fleet Materials Issues
- Reduce Alloy & Component Costs
Recent solicitations continue to develop solutions for existing and future fleets

**DE-FOA-0002002**

Enhancing the domestic supply chain for AUSC materials

- Phase I: $6M, Phase II: $20M
- Cyclic durability
- Reducing costs

**DE-FOA-0002192**

Addressing existing fleet material failure and repair

- $10M total funding
- Coatings
- Joining

Annual Fall Solicitation
Hydrogen – FE Strategy, Workshop, and RFI

Click here to download

USEA-hosted Workshop
July 23

Click here to download presentations

Hydrogen RFI
Responses Due August 24

1. Natural Gas Hydrogen Production, Transport, and Storage;

2. Hydrogen Production from Gasification of Wastes

3. Hydrogen Turbines

4. Hydrogen Storage

5. Hybrid Energy Systems with R-SOFCs

Click here for RFI
Workforce: Webinar, RFI and ARC Partnership

Materials 101 Webinar
NETL Regional Workforce Initiative
April 7

Workforce Development RFI
Responses Due August 31
1. Immediate Needs
2. Near-term Workforce Needs
3. Long-Term Adv. Materials Workforce Strategy
Click here for RFI

NETL & ARC Interagency Agreement
Appalachian Materials Workforce
August 14

To watch webinar, please click here.
4 Materials Panel Discussions

August 25
1. Program Update
2. NETL
3. SPS
4. Siemens
5. ORNL
6. GE

September 1
1. Energy Industries of Ohio
2. Siemens
3. PNNL
4. INL
5. Vacuum Process Engineering
6. GE

September 22
1. ORNL
2. WVU
3. Arconic
4. SWRI
5. PITT
6. DNVGL

September 29
1. NETL
2. CMU
3. LANL / XMAT
4. Penn State
5. EPRI
6. Missouri State
Today’s Objectives

1. **Update** you on FE’s High Performance Materials program

2. **Share** useful information on existing fleet

3. **Highlight** projects

4. **Hear** and **learn** from you

Image Source: Adobe Stock
Key Takeaways

• Supply chain benefits from this FE program
• Current and future challenges
• Coal and gas applications
• Driving down costs
• Reliability for flexibility
• Workforce
• Hydrogen

Calls to Action

1) Check out website
2) Let us know if you’re interested
3) Advise and partner on projects
   - Advisory Board for XMAT, partner on Lab work
4) Guide program - RFIs & workshops
5) HPC4Materials Solicitation
6) FOAs on FedConnect
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Program Website: https://www.netl.doe.gov/research/coal/crosscutting