Advanced Coal Processing Program

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NETL's Advanced Coal Processing Program



Program Goals

- Enhance the value and applications of domestic coal and coal wastes
- Develop new high-value products derived from domestic coal and coal wastes
- Advance laboratory and pilotscale technologies
- Expand coal databases to inform domestic and global customers

Program Focus Areas













Expanding the Coal Value Chain



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- NATIONAL ENERGY TECHNOLOGY LABORATORY
- Exciting opportunities to expand use of coal
- Advantages over other carbon-based feedstocks
 - Abundant and low cost
 - High-carbon density
 - Enables low cost, highvolume production of carbon materials
- Challenges
 - Optimizing product and process performance

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Product and Application Market Potential



Advanced Coal Processing Program

- Program is focusing on high-value and highgrowth products
- Current products and applications
 - \$96.3B global market value by 2023
 - CAGR of 9.2%
- Tremendous potential for domestic coal





Advanced Coal Processing Budget History







Recent Funding Opportunities

Funding Opportunity	Issue Date
FOA-0001992: Maximizing the Coal Value Chain	3/4/2019
FOA-0002185: Coal-derived materials for building, infrastructure, and other applications	4/10/2020
FOA-0002438: Design, R&D, Validation, and Fabrication of a Prototype Carbon-Based Building	12/11/2020
FOA-0002405: Advanced Coal Waste Processing: Production of Coal-Enhanced Filaments or Resins for Advanced Manufacturing and Research and Development of Coal-Derived Graphite.	04/16/2021



Current R&D Portfolio

Active Projects

- Program has 31 active projects
 - Three focus areas
 - Feedstock upgrading
 - Coal properties database
 - Coal to carbon products
- Carbon Products Include:
 - High Value
 - Graphene, quantum dots, conductive inks, battery anodes, synthetic graphite, and supercapacitor materials, carbon fibers
 - High Volume
 - Building materials, carbon foam, composites, roofing materials.





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Feedstock Upgrading



Pilot Plant Testing and Development

Carbon Fuels LLC FOA: 1849 Feb. 2019 – Jan. 2022 Total Award Value: \$3,166,443

The Novel Charfuel Coal Refining Process 18 Tpd Pilot Plant Project for Co-Producing an Upgraded Coal Product and Commercially Valuable Co-Products





Minerals Refining Company, LLC FOA: 1849 Feb. 2019 – Sept. 2021

Total Award Value: \$1,806,857

Pilot-Scale Testing of the Hydrophobic-Hydrophilic Separation Process to Produce Value-Added Products from Waste Coals





Coal Database

American Coal Database (ACD) and Virtual Beneficiation Platform (COAL DATA)



An Authoritative "Smart" American Coal Database & Virtual Beneficiation Platform to Optimize Coal Sources for Efficient and Effective End Uses

- Provides coal property, geochemical, and infrastructure data to coal producers and consumers
- <u>https://edx.netl.doe.gov/geocube/</u>



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FECHNOLOGY

Coal to Building Materials

NET NATIONAL ENERGY TECHNOLOGY LABORATORY

Revolutionizing Sustainable Building and Construction Materials

- High-volume and high-value products for coal
- Opportunities for coal
 - Increase product performance
 - Increase building energy-efficiency
 - Reduce product cost
- Products include
 - Carbon foam, roofing tiles, siding, decking, insulation, joists/studs, sheathing, and block
- FOA 2185: Building Materials
 - 14 projects recently selected to receive
 \$8.7 million
- FOA 2438: Prototype Carbonbased Building





FOA 2185: New Selected Projects



Coal-Derived Materials for Building, Infrastructure, and Other Applications

- Building Materials: 10 Projects
 - Coal-derived composites and pipe
 - Siding materials and architectural panels
 - Coal-based bricks & blocks and pavements
 - Carbon foam
 - Prototype carbon-based building
- High-Value Carbon Products: 4
 Projects
 - Graphene (2)
 - Silicon-carbon (Si-C) composite anode materials for lithium-ion batteries
 - Coal-derived quantum dots (CQDs)



















Example Coal to Building Material Projects



Semplastics

SBIR Grant Phase 1 – 2018 Phase 2 – 2019

Coal-core composite (CCC) for roofing tiles and other products



IERGY

Ohio U FOA: 1992 Awarded Sept. 2019

Coal plastic composite (CPC) for decking boards and other products **Battelle** FOA: 1992 Awarded Sept. 2019

Coal to polyurethane (PU) foam (solid) products **NETL - RIC** FWP-1022432 Initiated 2018

Coal-derived graphene used as an additive in ordinary Portland cement







Coal to Carbon Fiber

Producing High-Performance Materials from Coal

- Carbon fibers are strong light-weight materials
- Carbon Precursors include Polyacrylonitrile (PAN), Rayon, and coal tar pitch
- Program supports developments to enhance carbon fiber properties and production
- High carbon content, lower cost of coal tar pitch enable lower cost production







Coal to Carbon Fibers



Ramaco Carbon FOA: 1992 Awarded Sept. 2019

Raw coal feedstocks into pitch and carbon fibers



UKY FOA: 1992 Awarded Sept. 2019

Melt spinning coalderived pitch into fiber



Ramaco Carbon FOA: 1992 Awarded Sept. 2019

High-quality carbon fiber precursor material



ORNL and UKY FEAA155

C4WARD: Coal Conversion for Carbon Fibers and Composites



U. of Utah FOA: 1992 Announced Jan. 2020

Isotropic and mesophase coaltar pitch for carbon fiber production





Coal to Carbon Electrodes



George Washington U

FOA: 1992 Awarded – Sept. 2019

High value (Li-ion grade) "potato" graphite



Physical Sciences

SBIR Grant Phase 1 – 2018 Phase 2 – 2019

High-conductivity carbon material (HCCM) for electrochemical applications



Semplastics FOA: 1992 Announced Jan. 2020

Composite material for use in lithium ion (Li-ion) battery anodes



U. North Dakota FOA: 2185 Award: 2021

Lignite-Derived Carbon Materials for Lithium-Ion Battery Anodes







University of Illinois FOA: 1992 Awarded – Sept. 2019

High-value carbon nanomaterials and carbon sorbents



Rice U FOA: 1992 Awarded – Sept. 2019

> High-quality graphene



NETL - RIC FWP-1022432 Initiated 2018

Coal-based Carbon Nanomaterials



U. North Dakota FOA: 1992 Announced Jan. 2020

Laboratory-Scale Coal-Derived Graphene





Coal to Conductive Inks

Expanding Viable High-value, High-growth Markets for Coal

- Inks infused with conductive materials
- Enables printing of electrically conductive surfaces
- Facilitates production of flexible, stretchable, potentially self-healing electrical circuits
- Conductive carbon materials produced from domestic coal enables lower production costs







Conductive Inks

Minus 100

SBIR Grant Phase 1 – 2018 Phase 2 – 2019

New methods of manufacturing highly conductive ink pigments



3-D Printable Polymers

H Quest Vanguard

FOA: 1992 Awarded – Sept. 2019

Carbon and graphitic materials for industrial electrode applications and advanced 3-D printable carbon polymer composites



natural

aas



coal

platform chemicals, advanced carbons, hydrogen, fuels including graphene

Silicon Carbide Foam

Touchstone Research Lab

SBIR Grant Phase 1 – 2018 Phase 2 – 2019

New silicon carbon (SiC) foam utilizing coal feedstock for s-CO₂ turbine operation





NETL-RIC's Coal to Products Research

NETL's Research Innovation Center

TL ENERGY TECHNOLOGY LABORATORY

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Materials Discovery & Design



Market, Process, & Environmental Analysis



American Coal Database





Recent Accomplishments

NETL patent-pending technology converts coal into single-atom-thick carbon materials such as graphene



NETL coal-derived additive enables stronger and more durable cement at reduced cost



Coal-based nanomaterials manufactured at NETL are used to make computer memory devices





NETL's low-cost Coal to Graphene (C2G) technology was recognized with a prestigious R&D 100 Award.







- Exciting opportunities exist to create jobs, and produce high-value products, while reducing coal wastes
- New focus on building materials?
- Lab scale through pilot-scale development

Stakeholder involvement essential for transition of technologies to industry





Contacts



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