MISSION

Discover, integrate and mature technology solutions to enhance the Nation’s energy foundation and protect the environment for future generations

• Effective Resource Development
• Efficient Energy Conversion
• Environmental Sustainability

VISION

Be the Nation’s renowned fossil-energy science and engineering resource, delivering world-class technology solutions today and tomorrow

• Technology Convener
• Knowledge and Technology Generation Center
• Responsible Steward
NETL Snapshot

**By the Numbers**

- 3 labs across U.S.
- 900+ R&D projects in 50 states
- $6.3B total award value
- $991M FY19 budget

**Workforce**

- 1,226 Full Time Equivalent Employees (FTEs)
- 70 Joint Faculty
- 109 Postdoctoral Researchers
- 54 Graduate Students
- 40 Undergraduate Students

**NETL possesses an array of authorities to manage & implement complex R&D programs**

- Program planning, development, and execution
- Legal, Financial, Procurement and Head of Contracting Authority (HCA)
- Project Management Expertise

Data updated June 30, 2019
Coal Technology Thrusts

**Advanced Energy Systems**
Developing & deploying advanced, more efficient, & robust coal-based power technologies to optimize the use of our abundant domestic fossil energy resources & leverage existing infrastructure.

**Carbon Capture, Utilization, & Storage**
Advancing technologies & techniques to effectively capture, safely store, & economically utilize CO₂ derived from power generation & other industrial processes.

**Transformational Coal Pilots**
Developing pilot-scale transformational coal technologies aimed at enabling step-change improvements in coal-powered systems accelerating their readiness for the marketplace.

**Crosscutting Research**
Accelerating science & engineering-based solutions across multiple operational platforms to optimize plant performance, reduce O&M costs & water consumption, & develop the next-generation of structural & functional materials.

**STEP (Supercritical CO₂)**
Developing & modeling sCO₂ power cycles with the potential to achieve efficiencies greater than 50%, with broad applicability to fossil, nuclear, waste-heat, & concentrated solar energy power systems.

**NETL Coal R&D**
Developing novel extraction, processing, & manufacturing technologies to produce a cost-competitive domestic supply of rare earth elements from U.S. coal & coal by-products to sustain our Nation's robust economy.
Evolving Topics in Coal

**Upgrading the Existing Fleet**
- Improving the performance, reliability, & efficiency of the existing coal-fired fleet

**Advancing Next-Gen Power Plants**
- Advancing small-scale, modular coal plants that are highly efficient, flexible, & near-zero emissions

**Pioneering New Markets for Coal**
- Enhancing the value of coal as a feedstock & deriving new value-added products from coal

**Reducing the Cost of Carbon Capture**
- Developing advanced computational & simulation tools, & transformational technologies to reduce the cost of CO₂ capture

**Reducing Water Use in Energy Production**
- Addressing water quality, sustainability, & availability for power generation
Upgrading the Existing Fleet

NETL Focus Areas

- Sensors, Diagnostics, and Controls to Improve Prediction, Performance, and Reliability
- Power Plant Component Improvement
- Data Analytics Driven Controls

Reduced Mode Sapphire Optical Fiber and Sensing System

- With sponsorship by NETL, Virginia Tech developed harsh environment sensing technology.
- Researchers demonstrated in an industrial environment, advancing the technology from TRL 1 to TRL 7.
- Sensor system will enable real-time, accurate and reliable monitoring of temperatures inside a power plant’s boiler system, lowering operating costs through better operational control.
Addressing Advanced Material Challenges

**eXtremeMAT**

A joint research effort utilizing world-leading DOE National Lab resources:

- **Materials design**
- **High performance computing power**
- **Advanced processing & manufacturing**

- **In-situ characterization**
- **Performance assessment at condition**

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**Research Goals**

- Improving models to predict long-term materials performance
- Improving lower-cost, heat-resist alloys
Advancing Next-Gen Power Plants

NETL Focus Areas
• Modular power plants
• Stable power generation
• Flexible and highly efficient operations
• Accommodate ongoing transitions from simple arrangement to complex energy systems

Advanced Ultra-supercritical Technology

AUSC ComTest Project:
• Validating technology applicable to fossil, nuclear, and renewable power generation
• Accelerating development of domestic supply chain
• Higher efficiency and lower emissions
• Minimizing risk for building AUSC plants
• Designed world’s first integrated AUSC steam turbine at 760°C
Providing secure, stable, and reliable power

The R&D under the **Coal FIRST** initiative will support future power plants

- **Flexible** operations to meet the needs of the grid
- **Innovative** and cutting-edge components that improve efficiency and reduce emissions
- **Resilient** power to Americans
- **Small** compared to today’s conventional utility-scale coal plants
- **Transform** how coal technologies are designed and manufactured

**Design criteria includes:**
- High overall plant efficiency
- Unit sizes of ~50-350 MW
- Near-zero emissions
- High ramp rates and minimum loads
- Integration with thermal or other energy storage
- Minimized water consumption
- Reduced design, construction, and commissioning schedules from conventional norms
- Enhanced maintenance features
- Integration with coal upgrading, or other plant value streams
- Capable of natural gas co-firing
Pioneering New Markets for Coal

NETL Focus Areas

- Identify new manufacturing processes for converting coal into high-value products beyond traditional energy markets.
- Evaluate costs and technical performance of coal-based materials compared to derivatives of other feedstocks.
- Characterize the best markets for coal-based manufacturing and associated barriers.

Recovering rare earth elements from coal and coal by-product streams

- NETL is extracting rare earth elements (REEs) from the full spectrum of coal and coal-based materials.
- Supports three first-of-a-kind, domestic extraction, separation and recovery facilities.
- REEs are in the form of oxides and/or salts, which can either be directly used or converted into rare earth metals for end-use commodity.
Domestic Coal to High-Value Products

Enabling Marketable Carbon Products and Manufacturing Technologies

**COAL FEEDSTOCKS**

$30-60/ton

- Domestic Char
  (Sample from Virginia Carbonite)

**NEW ECONOMIC OPPORTUNITIES**

$100,000/ton - $100,000,000/ton

- Coal Processing Technology
  - Graphene-Enhanced Cement
  - Engineered Plastics
  - Low Cost Graphene Inks/Fluids
  - Carbon Quantum Dots

- Stain & Water Resistant Textiles
- Electronic Displays
- Pigments, Dyes, & Paints
- Optical Brighteners
- Photovoltaics & LEDs
- Carbon Fiber
- Additives for Construction Materials
- Carbon Nanomaterials
- 3D Printing Materials
Reducing the Cost of Carbon Capture

NETL Focus Areas

- Post-combustion: remove CO$_2$ from the combustion flue gas.
- Pre-combustion: capture CO$_2$ prior to combustion.
- Compression to increase the pressure and reduce the volume flow, enabling efficient transport.

Computational Tools to Rapidly Screening of Novel Carbon Capture Materials

- NETL in-house researchers used high-throughput computational methodology to screen over 1 million possible mixed matrix membranes (MMMs).
- NETL-developed polymers were found to enhance mechanical stability.
- MMMs, with NETL developed polymer, were estimated to decrease the cost of carbon capture from $63 to $48 per metric ton of CO$_2$ removed.
Additive Manufacturing Utilizing 3D Printing

Advancing scale-up and commercialization of carbon capture technologies

- Intensify thermodynamic operations
- Improve process performance
- Reduce equipment size
- Lowers capital and operating costs

ION uses 3D Printing to develop internal absorber mass transfer and heat exchange

ION

ORNL Prints Intensified Devices with Heat exchanger integrated into pack

LLNL creates silicon-based gyroid structures with one micrometer resolution

ION Engineering

ORNL

LLNL

ION

Baselining

Computational

Prototyping

Complementary Efforts
Reducing Water Use in Energy Production

NETL Focus Areas

- **Increasing** water efficiency and reuse to reduce water intake and lower overall operating costs.
- **Identifying** and treating alternative sources of water address energy-water system challenges.
- **Analyzing** energy-water system behavior to better inform decision-makers and scientists.

2018 Water Brief

- Identifies regions of water scarcity with expected growth in thermoelectric power generation.
- Recommends R&D to curb thermoelectric water use in areas of concern.
- Predicts locations that would benefit from R&D deployment.

Six potential geographic Areas of Concern that require an R&D plan are shown on a graphic of total available water (2010) overlaid with thermoelectric power generation (2018).
Technology Development Pathway

An Active Portfolio from Concept to Market Readiness

COMMERCIALIZATION
Technology available for wide-scale market use

DEMONSTRATION
System demonstrated in operational environment

SYSTEM TESTING
System performance confirmed at pilot-scale

DEVELOPMENT
Technology component validated/integrated

DISCOVERY
Concept identified/proven at laboratory-scale

KNOWLEDGE-BASED DECISION MAKING

• Systems Engineering and Integration
  • Engineering analysis
  • Pre-FEED/FEED studies
  • NEPA

• Decision Science and Analysis
  • Screening studies
  • Techno-economic analysis
  • Technology Readiness Assessments

Scale
Technology Confidence
Investment
Private Sector Cost Share
From Discovery to Commercialization

**Petra Nova CO₂ EOR CCS Plant**

**NRG W.A. Parish Power Plant – Full Scale Integrated CCS**

- **Government – Industry Partnership to Commercialization**
- **Technology Maturation**
- **Industry Leading the Effort**

**Scale Technology Confidence Investment**

**Discovery**
- Early 1990s: Proof-of-Concept Developed – Initial Carbon Capture Development (TRL 2-3)

**Development**

**System Testing**
- 2008: Pre-Commercial Prototype Validated in Relevant Environment (TRL 6-7)
- 2011: First-of-a-kind Integrated Coal CCS Small Commercial Scale Plant (TRL 7-8)

**Demonstration**
- 2016: Full Scale Commercialization
- 2016: First Commercial Plant - w/ Improved KM CDR Process® - 400 tons/day (TRL 9)

**Commercialization**
- 2016: First Commercial Plant - w/ Improved KM CDR Process® - 400 tons/day (TRL 9)
- 2016: First fully Integrated Coal CCS Plant – 500 tons/day (TRL 9)

**First of a kind**
- Integrated Coal CCS Small Commercial Scale Plant
- First fully Integrated Coal CCS Plant – 500 tons/day

**Alabama Power**
- Full Scale Commercialization
- Thomsens, TX – 4,766 tons/day est.

**Technology Confidence Investment**
- MHI/KEPCO Pilot Plant – 2 tons/day
- First Commercial Plant - w/ Improved KM CDR Process® – 400 tons/day
- First fully Integrated Coal CCS Plant – 500 tons/day
- First fully Integrated Coal CCS Plant – 500 tons/day

**Government – Industry Partnership to Commercialization**
- **Technology available for wide-scale market use**

- **System demonstrated in operational environment**
- **Technology component validated/integrated**
- **Concept identified/proven at laboratory-scale**
Established & Expanding Partnerships

An Active Portfolio from Concept to Market Readiness

FE has **over 600 partnerships with industry, academia and other government organizations** and funds **900+ R&D projects** nationwide.
How to work with NETL

• Cooperative Research and Development Agreement (CRADA)
• Contributed Funds-In Agreement (CFA)
• Memorandums of Understanding (MOU)/Memorandums of Agreement (MOA)

Available Technologies
• NETL’s technology portfolio contains a broad range of innovations that have resulted from research
• Technologies and IP available for licensing on NETL’s website.

Available Technologies: https://www.netl.doe.gov/business/tech-transfer/available-technologies

Funding Opportunity Announcement (FOA)
• NETL uses FedConnect.net, Grants.gov and FedBizOpps.gov to post FOAs
• Proposals and applications are only accepted electronically through FedConnect.net or Grants.gov

Funding Opportunities:
https://www.netl.doe.gov/business/solicitations
THANK YOU FOR VISITING!

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