Advanced Materials Manufacturing and Innovative Technologies for Natural Gas Pipeline Systems and Components

Cynthia A. Powell

Director, Office of Research & Development

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NATIONAL ENERGY TECHNOLOGY LABORATORY

NETL is the U.S. Department of Energy's premier energy research laboratory focused on fossil energy's contribution to national security, energy reliability, and environmental safety.
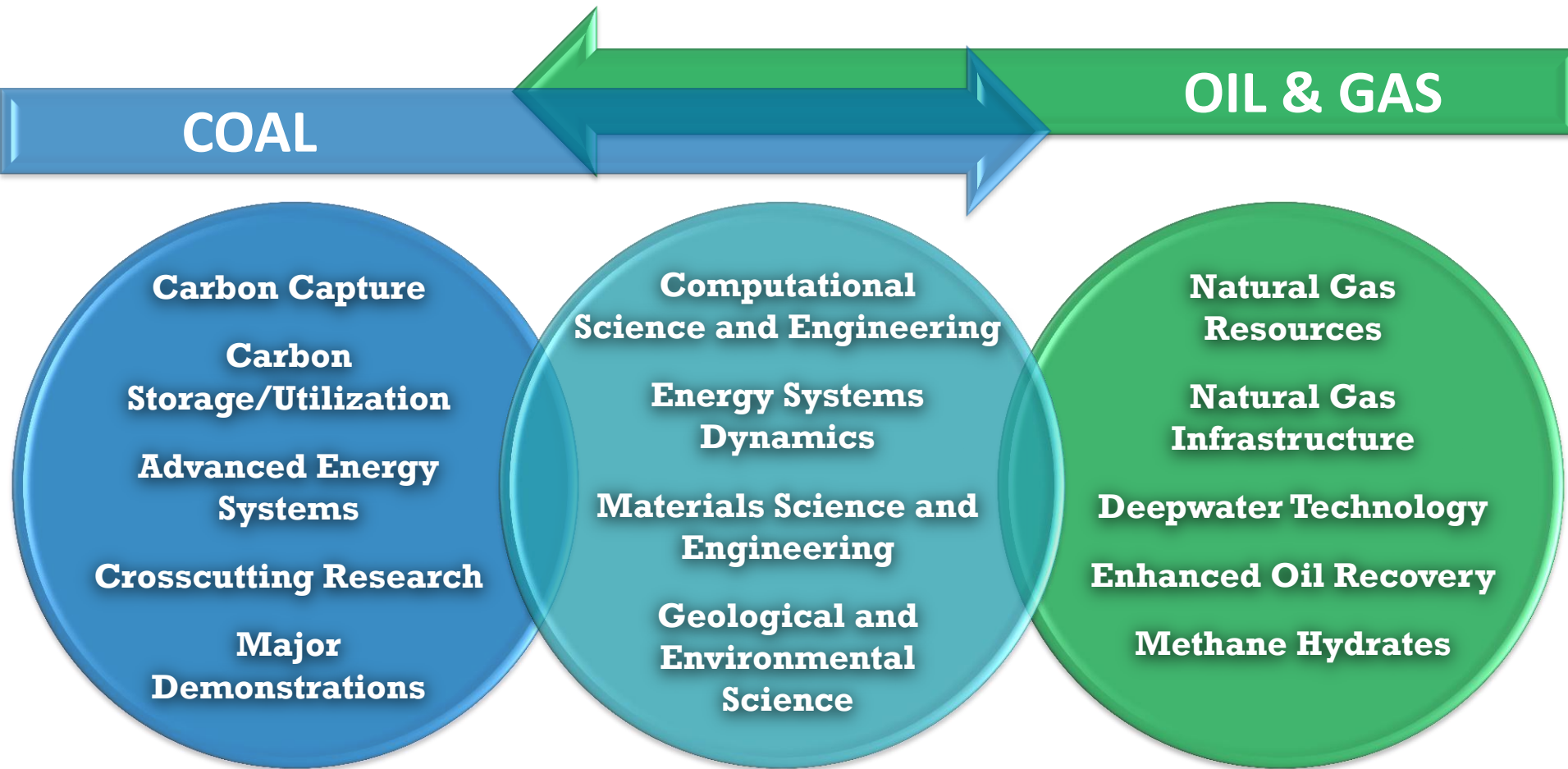
Delivers advanced technical solutions leading to continued affordable, reliable and clean use of the Nation's domestic fossil resources

Reduces technical risk through advanced simulations, laboratory testing and full-scale energy technology demonstrations

Builds a safer environment for future generations

FUELING OUR ECONOMY   STRENGTHENING OUR SECURITY   IMPROVING OUR ENVIRONMENT

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NETL TECHNICAL THRUSTS

COAL

OIL & GAS

Carbon Capture

Carbon Storage/Utilization

Advanced Energy Systems

Crosscutting Research

Major Demonstrations

Computational Science and Engineering

Energy Systems Dynamics

Materials Science and Engineering

Geological and Environmental Science

Natural Gas Resources

Natural Gas Infrastructure

Deepwater Technology

Enhanced Oil Recovery
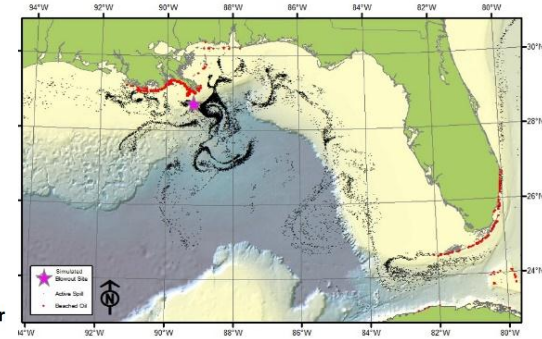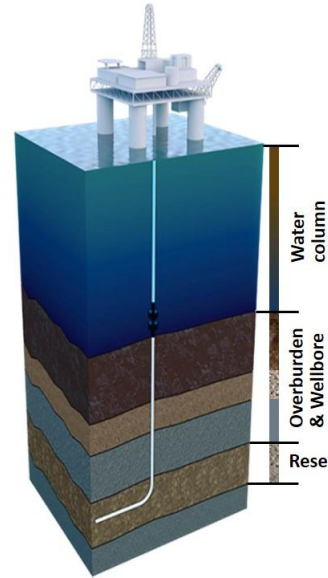
Methane Hydrates

Seamless, integrated on-site research and extramural collaboration

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NETL: Innovation in Fossil Energy Research
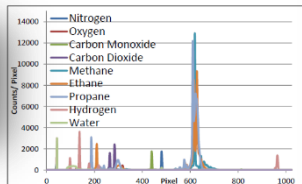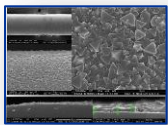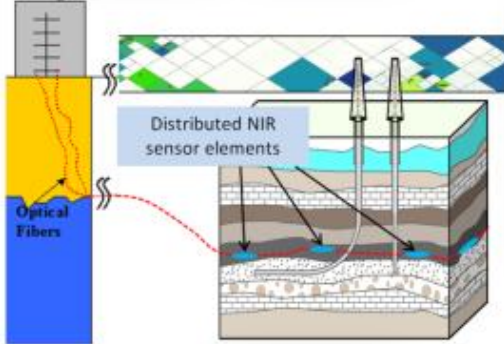

Alloy Discovery & Manufacture
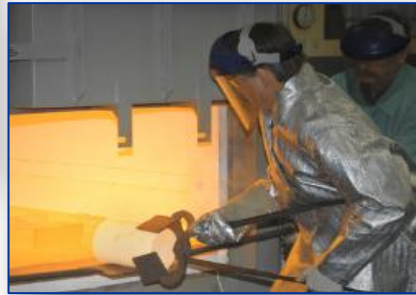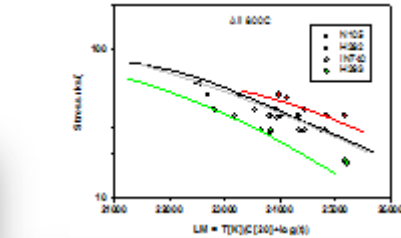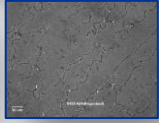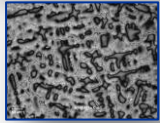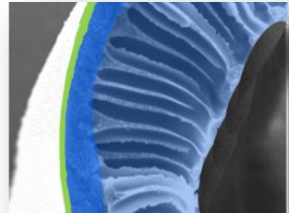
Integrated Risk Assessments

Sensors Technologies
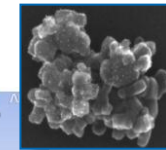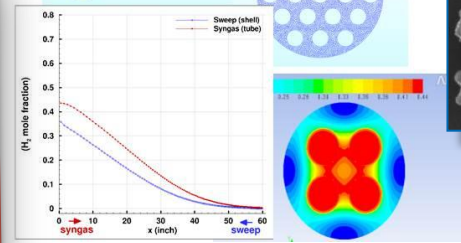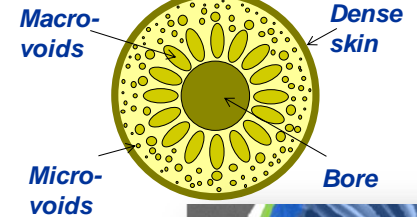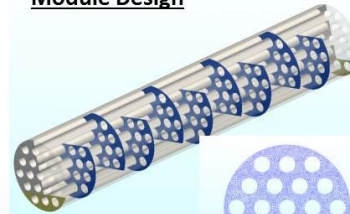
Gas Separations Reaction Engineering

Research Opportunities & Challenges
Advanced Materials Manufacturing & Innovative Technologies

- **Leverage additive manufacturing technologies in the production of high performance transmission and distribution pipelines.**
  - Opportunities:
    - Minimize Number of Joins
    - Incorporate Mitigation Strategies into Pipe Build (graded structures, permeation barriers, sensors, …)
  - Challenges:
    - Manufacturing Methodology MUST be Able to Deliver Required Materials Performance (microstructure control!)
    - Scale-up – Millions of miles of pipeline will be needed, at sizes ranging from 2" to 48" in diameter.

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Research Opportunities & Challenges
Advanced Materials Manufacturing & Innovative Technologies

- **Develop Integrated Risk Assessment Models that Incorporate a Validated, Science-Based Understanding of Materials Performance *at Condition* to Inform Integrity Management Plans.**
  - Opportunities:
    - Leverage advances in high-performance computing and improved understanding of materials performance at condition.
    - Incorporate data management/artificial intelligence to accelerate development of optimized materials.
    - Create a simulation-based toolset that is useable by industry to inform, and ultimately provide the basis, for Integrity Management Plans.
  - Challenges:
    - Integrating models across size and time scales consistent with the application and a variety of potential failure mechanisms (chemical, mechanical, etc.).
    - Quantifying the uncertainty behind model predictions.
    - Broad acceptance that such integrated risk assessment models are sufficiently accurate.

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Research Opportunities & Challenges
Advanced Materials Manufacturing & Innovative Technologies

- **Develop and Incorporate Robust Sensor Networks in Transmission and Distribution Pipelines that Can Continuously and Remotely Monitor Pipeline Health and Inform Integrated Risk Assessment Models.**
  - Opportunities:
    - Provide an early warning system that can enable corrective actions before catastrophic failures occur.
    - Validate fugitive emissions from pipelines.
    - Incorporate data management/artificial intelligence to maximize learning/understanding from sensor networks.
  - Challenges:
    - Development of affordable sensor materials and network packaging and communication systems that are sufficiently robust and reliable to survive years in service.
    - Reliable communication of useful information to the operator in real time.

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Research Opportunities & Challenges
Advanced Materials Manufacturing & Innovative Technologies

- **Develop and Incorporate Robust Sensor Networks and Controls in Natural Gas Compression Systems that Can Continuously Monitor and Optimize System Performance.**
  - Opportunities:
    - Improved compressor efficiencies and better response to changing gas demand profiles.
    - Sharply reduced green house gas emissions from compressor exhaust.
  - Challenges:
    - Development of affordable sensor materials and network packaging and communication systems that are sufficiently robust and reliable to survive years in service.
    - Manufacture of sensor platforms and embedded sensors.

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Research Opportunities & Challenges
Advanced Materials Manufacturing & Innovative Technologies

- **Develop Modular Reactor Systems Designed to Convert Compressor Exhaust From an Environmental Concern to a Value-Added Product Stream.**
  - Opportunities:
    - Leverage improvements in separations materials technologies, combined with advances in additive manufacturing to produce affordable, modular reactors for compressor stations.
    - Process intensification that integrates gas separations and reaction engineering to optimize reactor design.
  - Challenges:
    - Development of a modular reactor that can seamlessly incorporate into a compressor station, without impacting system operations/efficiency.

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Research Opportunities & Challenges
Advanced Materials Manufacturing & Innovative Technologies

- **Develop "Born Qualified" Pipe Materials that are Corrosion Proof, Impermeable, and Strong (Enough), and which are also Self-Monitoring and Self-Healing.**
  - Opportunities:
    - Create an environmentally-sustainable gas transmission and distribution pipeline system that is essentially maintenance free.
  - Challenges:
    - Balancing multiple materials performance requirements criteria in an optimized material.
    - Affordability.
    - Reliable production of composite materials at scale.

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A CLEAN AFFORDABLE ENERGY FUTURE