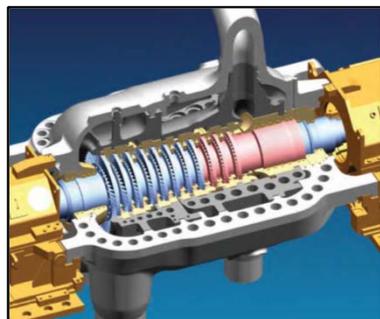
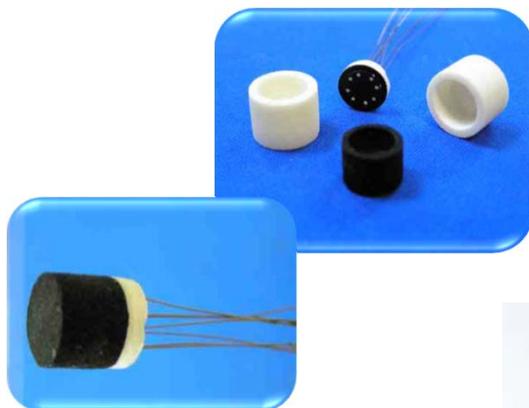
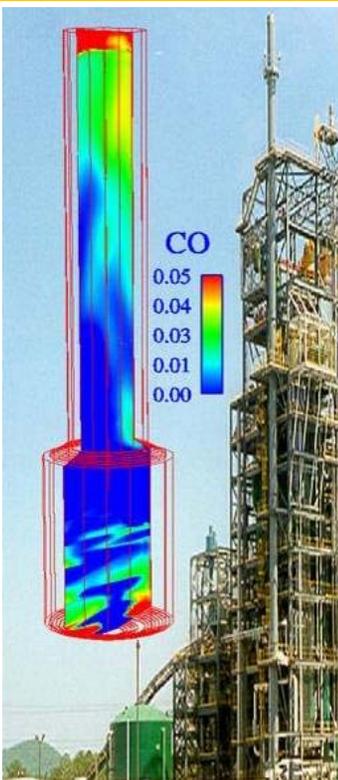




Driving Innovation ♦ Delivering Results

Seminar on NETL's Minority Serving Institutions Program

Crosscutting Technology Research at NETL



Steven Seachman

Project Manager, Crosscutting Research Division

Office of Coal and Power R&D

October 29, 2015



National Energy
Technology Laboratory

Crosscutting Technology Research



Crosscutting Technology Research *Targets Support Across Multiple Program Areas*

National Energy Independence and Reduced Emissions



Key Technologies

- High Performance Materials
- Sensors & Controls
- Simulation-Based Engineering
- Water Management R&D
- Innovative Energy Concepts

Key Drivers

- Higher Efficiency
- Process Intensification
- Improve Design Tools
- Improve Process Control
- Lower Water Use

Crosscutting Research

Enabling Technology Advancement



Bridging the gap between fundamental research and applied development to support advancement and utilization of domestic energy resources.

- Crosscutting science, tools, and technology development program is supported by Industry
- Has a 15-25 year horizon for technology that supports breakthrough concepts, addresses gaps, develops products with commercial application – *near-term* and *long-term*
- Innovation through fundamental and applied developments that benefit Fossil-based Energy Systems (largely coal focused)

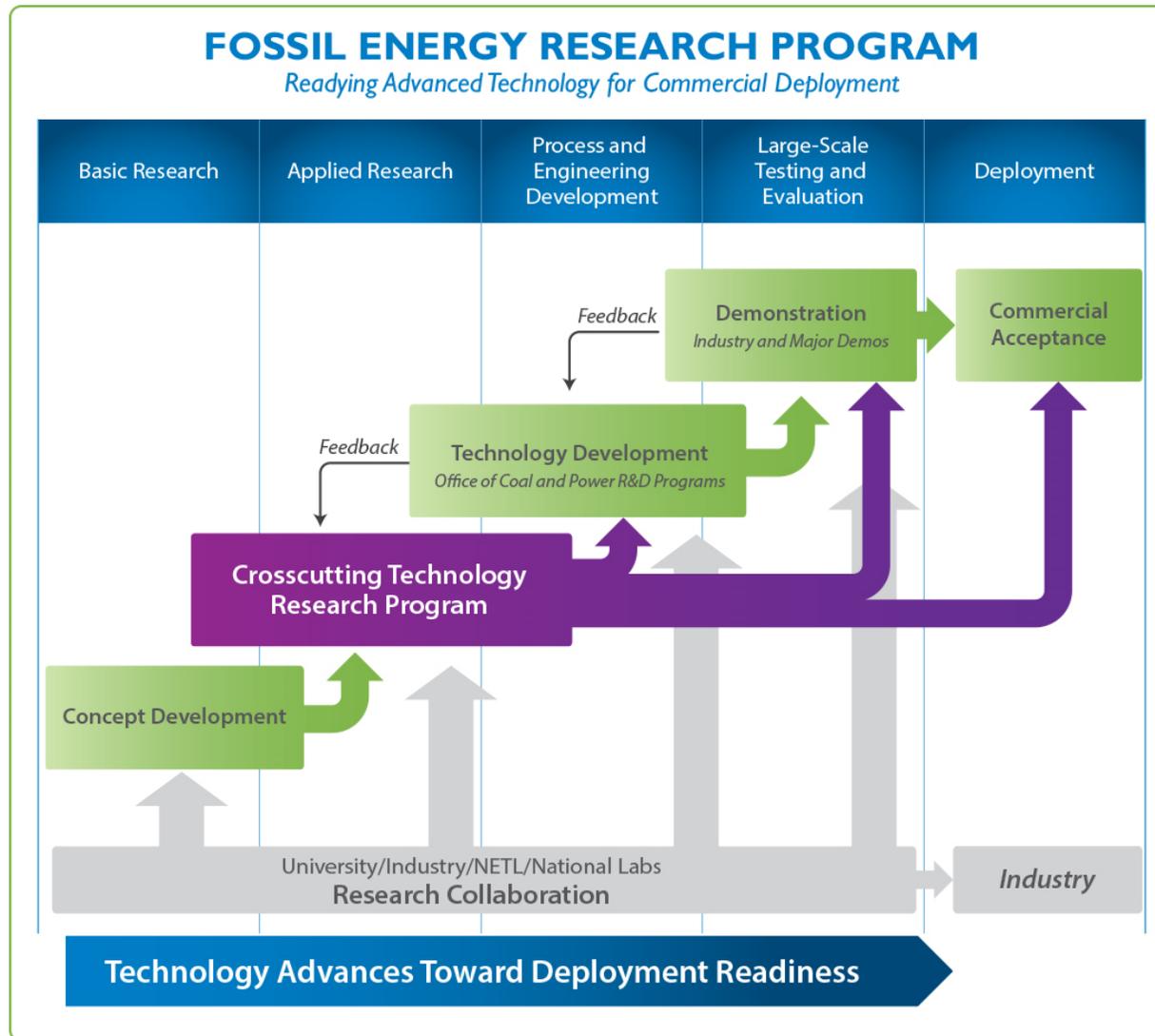
Crosscutting Research Focuses on Enabling Technologies that apply across multiple platforms

- High Performance Materials
- Sensors and Controls
- Simulation-Based Engineering
- Water Management
- Innovative Energy Concepts
- University Training and Research (UTR)

Fostering transformational developments in power system design, construction, and operation for highly efficient operation and superior environmental performance.

FOSSIL ENERGY RESEARCH PROGRAM

Readying Advanced Technology for Commercial Deployment



Crosscutting Research

Program Benefits – Technology Can Realize Industry Benefits



Improving HEAT RATE by 1%

- ❑ Refurbishing the U.S coal fired fleet with improved technologies and optimal controls has the potential to reduce CO₂ emissions by over 14.4 million metric tons per year for every 1% heat rate improvement
- ❑ Results in low cost per ton of CO₂ avoided — \$2-\$10/mt CO₂

Increasing AVAILABILITY by 1 %

- ❑ For example sensors and controls technology has potential to reduce forced outages by 10% and making it economical for the coal fleet to refurbish at capital cost under \$1 million
- ❑ 500 MW coal fired units could produce an additional 44 million kWh/yr in added generation for each 1% improvement in availability, resulting in ≈\$2.6 million/yr in sales (@ 6 cents/kWh)

Heat Rate and Availability Improvements of 1% Are easily achievable.

Entire coal-fired fleet

\$358 million / yr coal cost saving
A reduction of 14.4 Mt CO₂ / yr
More than 2 GW of additional capacity

Power

3.5 Billion kWh/yr
@ 80% capacity factor

Coal

35,700 MMBTU/yr
\$70 Million/yr
@ \$2/MMBTU

High Performance Materials Program



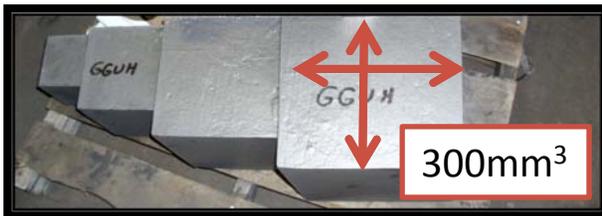
Design,
Fabricate and
Test

Structural

Functional
Materials

Advanced
Manufacturing

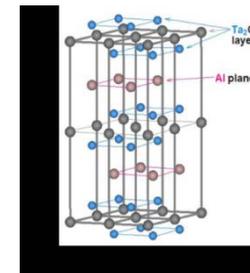
Computational
Materials Design



Haynes 282 and Alloy 263
Step Castings 135-450kg
sizes (300 to 1,000 lbs)



Simulated casting weld
defect repair



Oxygen Carrier Pellets for Chemical
Looping Prepared from Extrusions
(University of Toledo)



World's First Haynes 282 Triple Melt Ingot



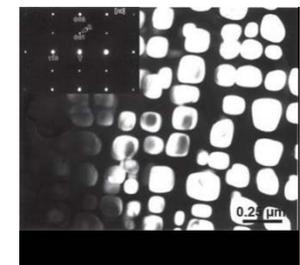
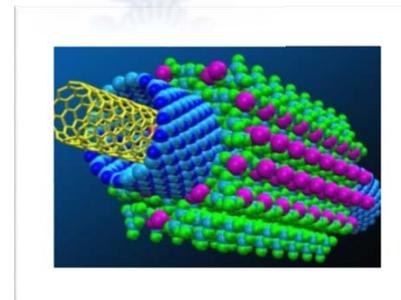
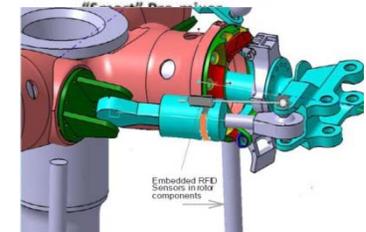
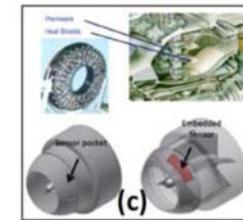
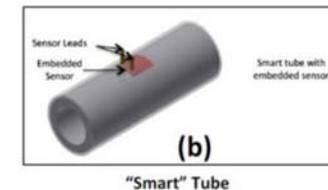
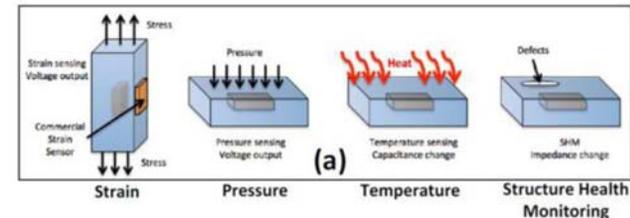
U.S. DEPARTMENT OF
ENERGY

National Energy
Technology Laboratory

Advanced Manufacturing Technologies Crosscutting Projects on Leading Edge



- **Next Generation Materials**
 - Advanced Materials
 - Membranes
 - Catalysts
 - Material Genome Initiative
 - Advanced Sensors
 - Advanced Coatings
 - Next Generation Electronics
- **Next Generation Manufacturing Processes**
 - Additive Manufacturing
 - Nanomanufacturing
 - Bio-manufacturing
 - Modular Process Intensification
 - Roll-to-Roll Processing
- **Improved Manufacturing Systems**
 - Smart Manufacturing
 - Automation and Robotics
 - Simulation and Visualization
 - Sustainable Manufacturing

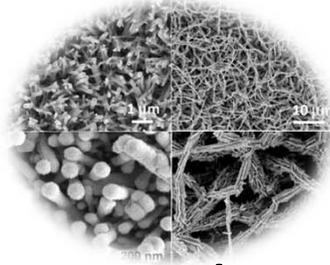


50% of NETL Projects w/Advanced Mfg Concepts are Crosscutting Projects



U.S. DEPARTMENT OF
ENERGY

National Energy
Technology Laboratory

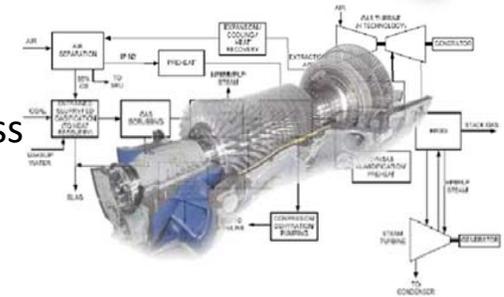


**Transformational Development For
On line Monitoring and Process Control**
Faster Response, Improved Knowledge, Better Control



Advanced Sensing and Remote Monitoring

- Harsh environment sensing concepts and approaches for low cost dense distribution of sensors
- Exploration of Sensor Networking using Passive and Active Wireless communication, Thermoelectric and vibration energy harvesting approaches

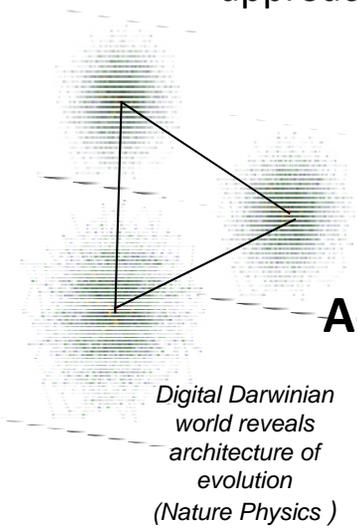
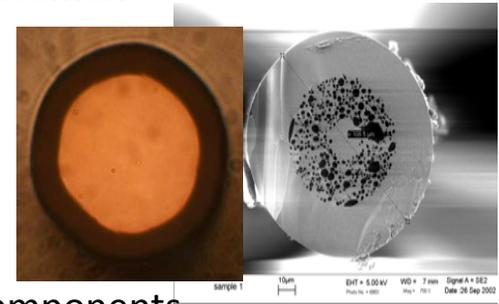


Distributed Intelligence

- Computationally driven approaches for novel control architectures and logic, information generation, sensor networking & placement
- Manage complexity inherent to Advanced Systems
- Achieve Performance with Competing Objectives

Advanced Manufacturing Sensors

- Pressure, Strain, Temperature, Impedance Defect
- Basis for integrating sensors into systems, and
- Integration of sensors into design and fabrication of components
- AM techniques to lower cost and improve fabrication



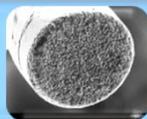
Digital Darwinian world reveals architecture of evolution (Nature Physics)

Sensor & Controls R&D Areas



Optical Sensors

- Spectroscopic
- Non-contact
- Fiber based

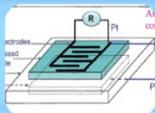


Optical Access, Interference management

Single Point, Distributed and Multiplexed Sensors, Coatings for sensing, protection, and attachment

Micro Sensors

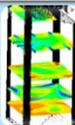
- Single point
- Array based



Materials for active sensing layers & protective coatings, Algorithms for Gas Quantification, Sensor Packaging, lead wire & connector improvements

Other Sensors

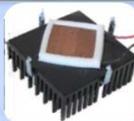
- Embedded sensors
- Imaging



Active films, direct write sensors, Metamaterials, Capacitance Imaging, Algorithms for image reconstruction

Enabling Technologies

- Wireless Energy Harvesting



Passive Wireless, Active Wireless communication, Thermoelectric and vibration energy harvesting approaches, Sensor Networking

Controls Technologies

- Distributed Intelligence

Computationally driven approaches for novel control architectures and logic, information generation, sensor networking & placement

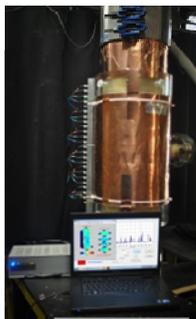
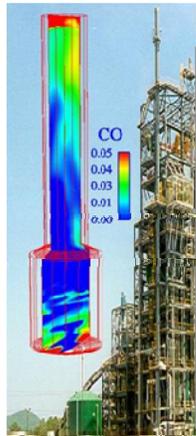
Novel Controls

- Sensor Placement
- Control and Optimization

Biomimetic control, learning algorithms, setpoint optimization, hybrid plant control, and actionable information



Simulation-Based Engineering for Technology Development



Technical Knowledge

Collaborative Partnerships

Code & Software Development

Accelerated solutions for complex power systems

Experimental Facilities

Computational Power

Data Repository



Water Management Research Focus Areas

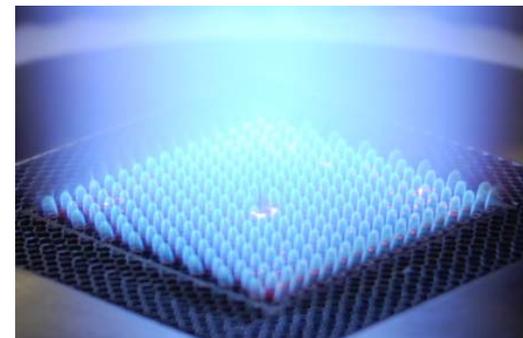


- **Advanced / Novel Heat Transfer and Cooling Systems**
 - *Wet, Dry, Hybrid*
 - *Incremental & Step Change Improvements*
 - *Advanced Manufacturing of Recuperators for Combustion Turbines*
- **Water Treatment and Reuse**
 - *Economic Pathways for Zero Liquid Discharge*
 - *Treatment of high TDS Waters (promote greater Water Reuse – collaboration with CS)*
- **Process Efficiency and Heat Utilization:**
 - *Pathways for produce more power per unit of water withdrawn, consumed, and treated*
 - *Utilization of Low-Grade Heat*
 - *Bottoming Cycles*
- **Data, Modeling and Analysis**
 - *Tools to enable regional and plant level decision making*
 - *Develop a National Water Atlas*
- **Breakthrough or Out of the Box**
 - *Low / No water FE based Systems, Distributed Generation, Grid Upgrades*

Innovative Energy Concepts Incubator to Enable Advanced Transformative Technologies



- **Transformative improvements in Electricity Generation and Delivery**
- **System Studies to validate concepts and understand economics of the technologies**
- **Recent Studies:**
 - Direct Power Extraction
 - Thermoelectric Materials
 - Pulse Detonation/Pressure Wave Combustion
 - Plant Flexibility Concepts
- **Conduct basic research to develop & validate computational tools**
- **Expand basic research to improve critical components for technology to reach potential**



Educational Grant Programs

Annual Solicitation for Fossil Energy Related Research



University Coal Research (UCR)

- Sustain a national university program of fossil energy research that focuses on innovative and fundamental investigations pertinent to fossil fuel conversion and utilization
- Provide a future supply of scientists and engineers through research exposure in clean energy fossil technologies
- Improve our fundamental scientific and technical understanding of chemical and physical processes involved in the conversion and utilization of fossil fuels



Historically Black Colleges & Universities and Other Minority Institutions

- Provide and promote opportunities for HBCU/OMI in science and engineering.
- Foster private sector participation and interaction with HBCU/OMI in fossil energy-related programs.
- Provide a forum to facilitate technology transfer, strengthen educational training, and develop/enhance the research infrastructure capabilities of HBCU/OMI.

Useful Links



NETL

www.netl.doe.gov



Office of Fossil Energy

www.fe.doe.gov

Crosscutting Research

<http://www.netl.doe.gov/research/coal/crosscutting>

Project Portfolios/Publications

<http://www.netl.doe.gov/research/coal/crosscutting/publications>

Project Information

<http://www.netl.doe.gov/research/coal/crosscutting/project-information>



U.S. DEPARTMENT OF
ENERGY

National Energy
Technology Laboratory

Contact Information



Robert R. Romanosky

304-285-4721

Robert.Romanosky@netl.doe.gov

Steven M. Seachman

304-285-5448

Steven.Seachman@netl.doe.gov



U.S. DEPARTMENT OF ENERGY

National Energy Technology Laboratory



For More Information, Contact NETL

the ENERGY lab

Delivering Yesterday and Preparing for Tomorrow

