NATIONAL ENERGY TECHNOLOGY LABORATORY

Clean Fossil Fuel: Opportunities for Cooperation

Rebuilding the Transatlantic Bridge: U.S.-Polish Cooperation on Science, Technology, and Innovation

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Advanced Research

Strategic Center for Coal

Washington, DC
December 3-4, 2009

National Energy Technology Laboratory

- Only DOE national lab dedicated to fossil energy
  - Fossil fuels provide 85% of U.S. energy supply
- One lab, three research campuses
- 1,200 Federal and support-contractor employees
- Research encompasses fundamental science through technology demonstration

Pennsylvania

West Virginia

Oregon

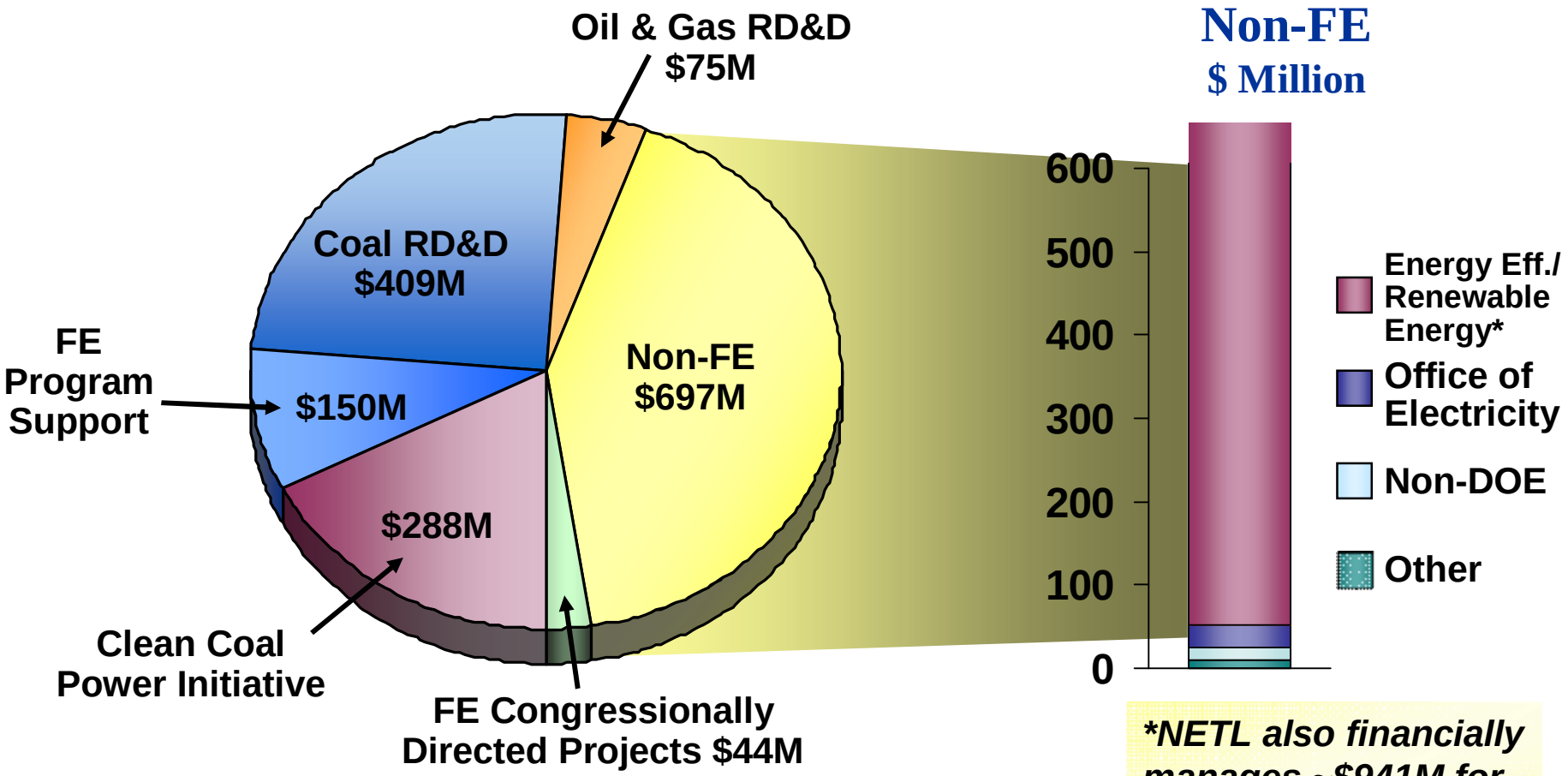
National Energy Technology Laboratory

Advancing Energy Options to Fuel our Economy, Strengthen our Security, and Improve our Environment

- Only government owned & operated DOE national laboratory
- Dedicated to energy RD&D
- Fundamental science through demonstrations
- Unique industry–academia–government collaborations
- >600 Federal employees and >600 onsite contractors
- Over 1,300 activities in U.S. and >40 foreign countries with total award value of ~$11B including ~$6B in private sector cost-sharing
- FY2009 budget $2.6B + $18.9B under 2009 American Recovery and Reinvestment Act + financial management of ~$941M for EE/RE

NETL'S 5 FACILITIES

NETL FY 2009 Budget



Note: In addition to NETL's FY 2009 budget of $2.6B, NETL will implement programs valued at $15.5B under the American Recovery and Reinvestment Act of 2009

**NETL also financially manages ~$941M for EERE's Project Management Center*

U.S. Commitment to CCS
Largest Investment of any Nation

- **DOE Secretary Steven Chu, at Ministerial Meeting of Carbon Sequestration Leadership Forum on 12 October 2009, in London, noted:**
- **$4 billion from federal government matched by ~$7 billion more from U.S. industry**
  - $1.4B for 5 commercial coal-fired power plant CCS demonstrations
  - ~$1.6B for 5 industrial CCS retrofit demonstration projects
  - ~$100M for beneficial CO_2 reuse demonstration projects
  - $50M to evaluate geological formations for large-scale CO_2 storage
  - $20M training grants to develop necessary workforce
  - ~$400M to develop new CO_2 capture and compression technologies
  - >$500M over next 10 years for sequestration science and monitoring through 7 DOE Regional Carbon Sequestration Partnerships
  - >$1B for FutureGen

Strategic Center for Coal

All Programs Support DOE Goals for Energy Security

- ***Energy diversity***
- ***Environmental impacts***
- ***Energy infrastructure***
- ***Energy productivity***

Demonstration Program

Clean Coal Power Initiative

Carbon Capture Demonstration Initiative

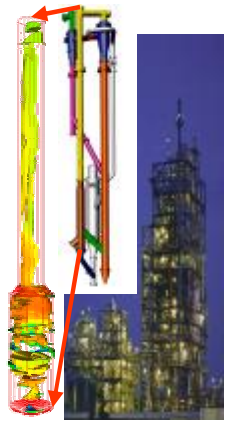
FutureGen

Clean coal power generation with carbon capture and storage

Core R&D Program

FY10 Program Components & Funding

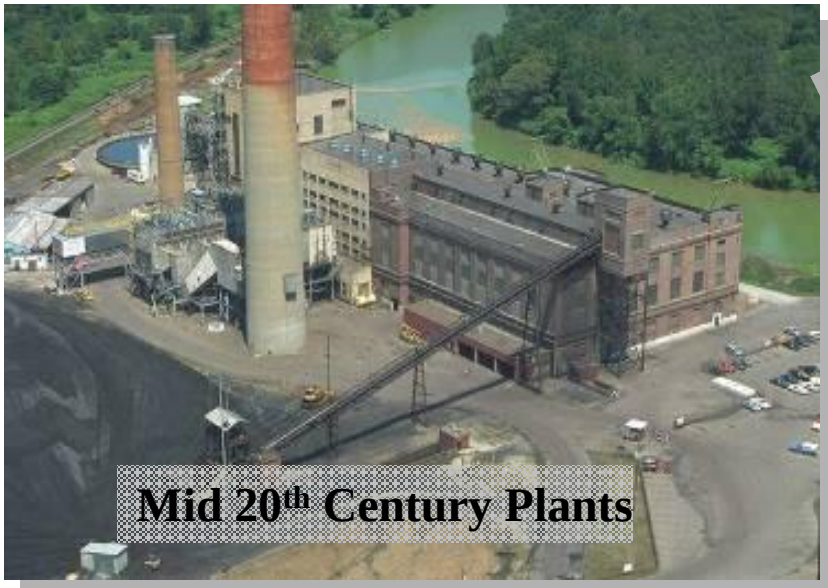
- **Innovations for Existing Plants ~$52 Million**
- **Gasification ~$63 Million**
- **Turbines ~$32 Million**
- **Fuel Cells ~$50 Million**
- **Sequestration ~$154 Million**
- **Fuels ~$25 Million**
- **Advanced Research ~$28 Million**
- **FutureGen ~$1 Billion (ARRA Funding)**
- **Clean Coal Power Initiative ~$800 Million (ARRA)**



Technology Challenges

Related to Advanced Research

- **Zero emissions** including carbon control
- **System Integration**
- **Controllable and reliable designs**
  With tight tolerances & operating margins
- **Advanced Designs** - E.g. oxy-combustion, chemical looping, water minimization
- **High temperatures & pressures**



- **Process modeling**
- **Operating efficiency**
- **Dynamic & transient mode control**
- **Durable structural materials**
- **Advanced separations and coatings**
- **Diagnostics for harsh environments**

Contribution from Sensors and Controls

Value Derived for an Existing Coal Fired Power Plant

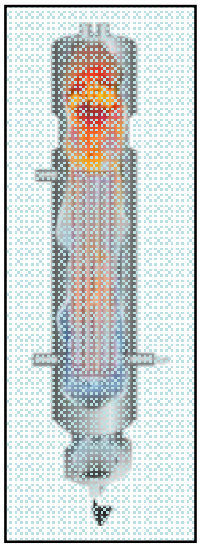
- **1% improvement in EFFICIENCY**
  - $468,000 savings in fuel
  - $4.9 million for entire installed fossil capacity
- **REDUCTIONS in greenhouse gases and solid wastes**

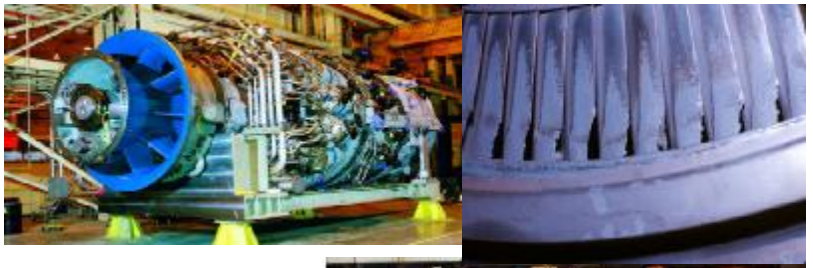
- **1% increase in AVAILABILITY**
  - Yields 33 million kw-hr/yr added generation for a 500MW plant
  - Approximately $2 million in sales (at $60/1000kw-hr)
  - An additional 5,000 MW of power for entire installed fossil capacity

Fossil Energy Key Material Research Areas

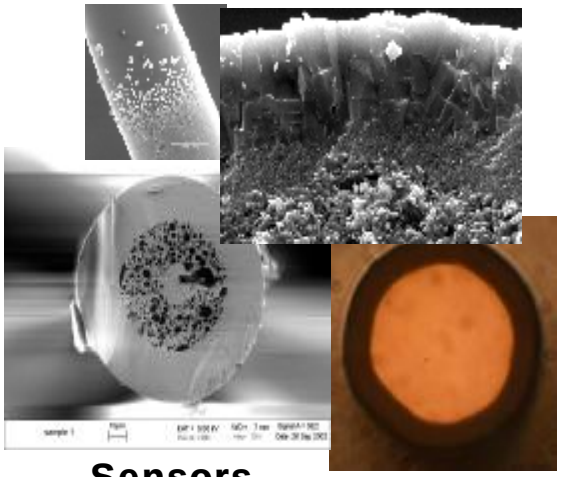
USC Boilers/Turbines

Gasifier

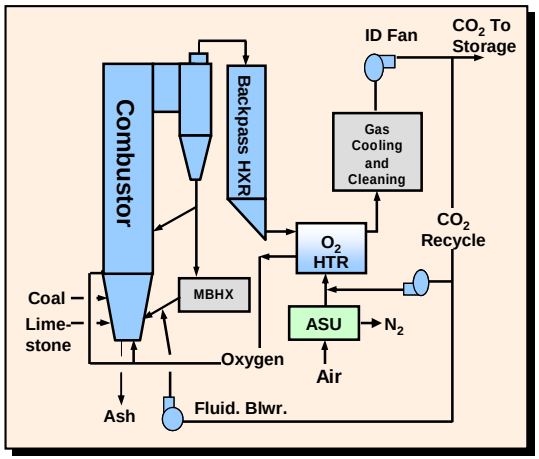




Advanced Turbines



Sensors

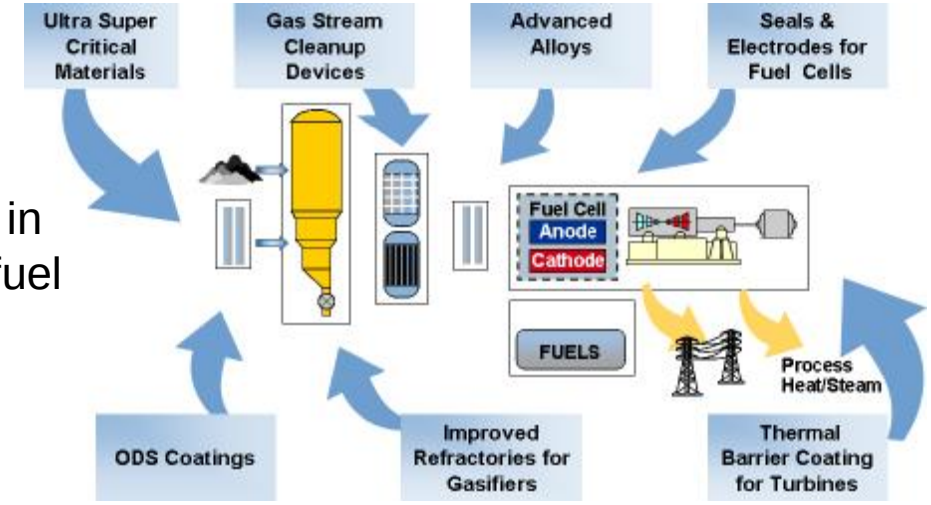


Oxy-Firing

Fuel Cells

High Performance Materials Research Areas

- **New Alloys** - Increase temperature capability of alloys for use in specific components through developments in composition, microstructure, and properties.
- **Functional Materials** - Special requirements of materials for specific conditions such as those encountered in hot gas filtration, gas separation, and fuel cell systems.
- **Coatings & Protection of Materials** - Develop the design, application, and performance criteria for coatings to protect materials from the high-temperature corrosive environments encountered in advanced fossil energy plants.
- **Breakthrough Materials** - Explore materials development with temperature/strength capabilities beyond those currently available.

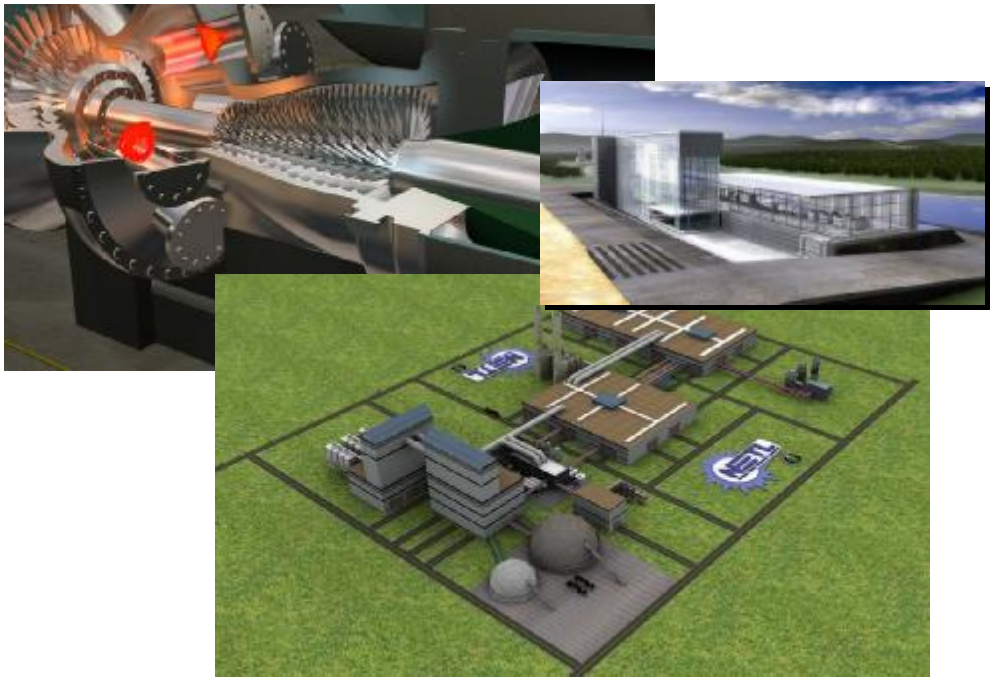


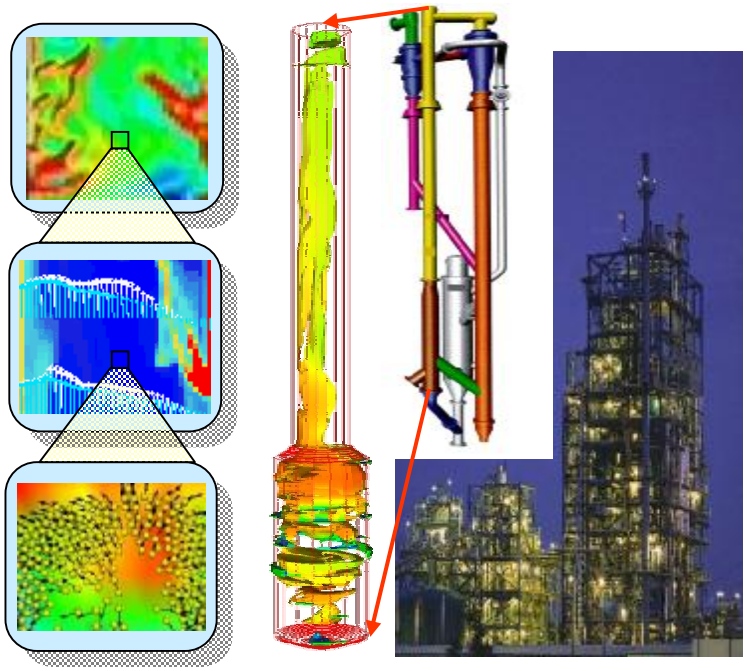
- **Ultra Supercritical Materials** – Develop materials technologies for advanced steam cycles in coal-based power plants to operate at steam conditions of up to 760°C (1400°F) and 5,000 psi .

Computational Energy Sciences Program

Goal

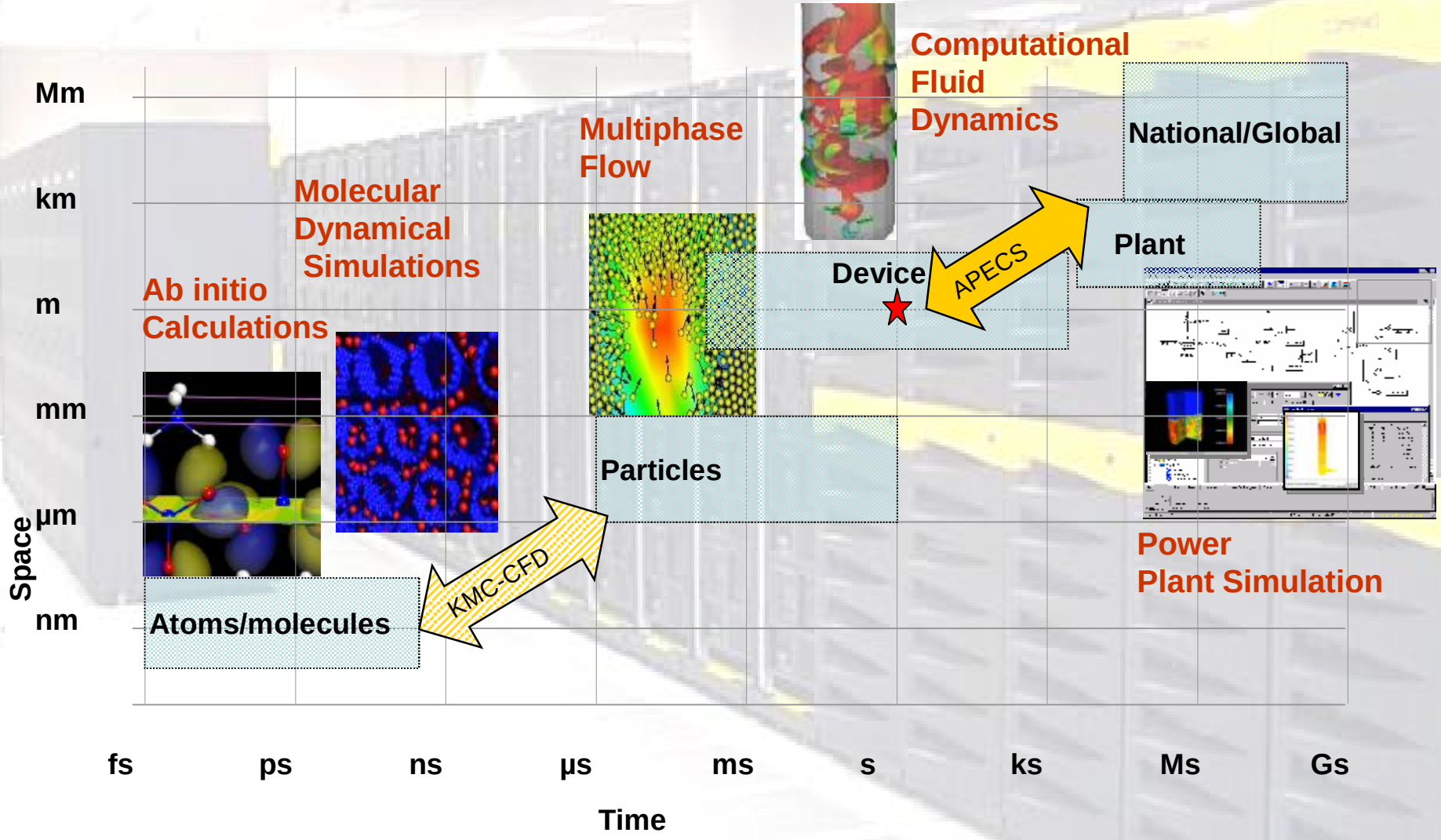
Development, Validation and Application of Simulation and Visualization Tools to Create a "Virtual Power Plant"





Simulation & visualization speeds design, reduces risk, and saves money
Barriers to FE program can be analyzed and resolved cost effectively

Computational Science at NETL



Office of Research and Development

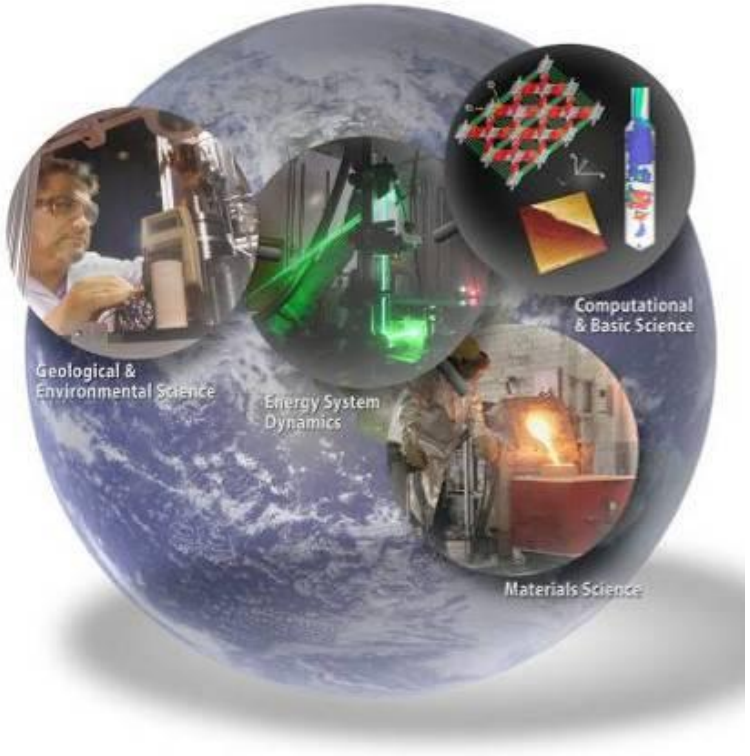
Innovative Advanced Energy Technology

Focus Areas

- Computational and Basic Sciences
- Energy System Dynamics
- Geological and Environmental Systems
- Materials Science

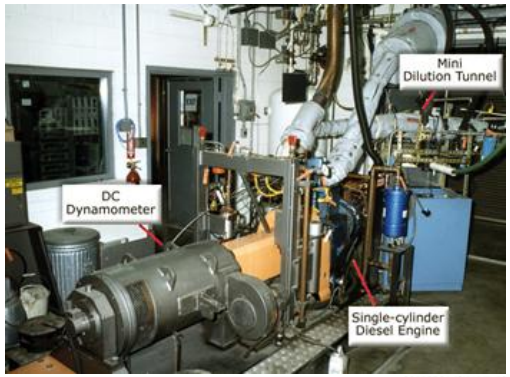
Key Initiatives

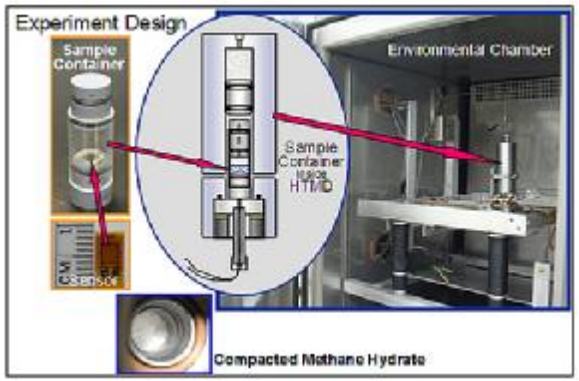
- Advanced carbon management technologies
- Predictive computational tools
- Advanced combustion control & simulation
- Technologies for extreme deep resources development
- Advanced materials processing & development



NETL's Core In-House R&D Capabilities & Facilities

- Carbon management
- Chemical reaction engineering
- Combustion science
- Computational research
- Environmental science
- Fuel cells research
- Geosciences
- High temperature/high pressure science
- Materials performance
- Methane hydrates research
- Process development
- Reciprocating engines research
- Remote sensing
- Sensors and controls
- Separations science
- Surface science





Institute for Advanced Energy Studies

NETL's University Research Initiative

- *Carnegie Mellon University*
- *University of Pittsburgh*
- *West Virginia University*
- *Penn State University*
- *Virginia Tech University*

Universities provide expertise in basic science and engineering to catalyze and strengthen NETL's onsite R&D capabilities

Fiscal Year	Funding
2005	$2.5 M
2006	$7.3 M
2007	$10.3 M
2008	$15.1 M
2009	$7.5 M
TOTAL	$43.7 M

Leveraging national lab and university-based scientific and engineering assets to address significant national energy issues

Central Mining Institute/Institute of Chemical Processing of Coal (Poland) MOU

- **Duration: 2008 – 2013**
- **Areas of cooperation:**
  - Coal-based technologies for clean power generation
  - Advanced coal combustion technologies
  - Emissions control technologies
  - CCS and transport technologies
  - Coal conversion technologies
  - Underground coal gasification
  - Chemical looping
  - Advanced materials
  - Consultation on formation of Polish Clean Coal Technology Center

- **Initial 1-month assignment of ICPC researcher at NETL on chemical looping in February 2009**
  - Joint publications being prepared

New Potential U.S./Poland Area of Collaboration

- **Participants: NETL, Ohio Coal Development Office, Energy Industries of Ohio**

- **Ultrasupercritical Materials Processing Research Area**
  - Poland is renowned for unique metal casting research
  - Foundry Research Institute, with their subsidiary on-site production plant, provides for real world credibility
  - FRI is developing an optimized casting process for newly identified high nickel alloys needed for the U.S. Ultrasupercritical Program

DOE/FE Bilateral Fossil Energy Protocols

- **DOE and China's Ministry of Science and Technology**
  - Scientific and technological cooperation in fossil energy, particularly activities related to research, development, demonstration, and deployment
  - Annex I: Power Systems; Annex II: Clean Fuels; Annex III: Oil and Gas; Annex IV: Energy and Environmental Control Technologies; Annex V: Climate Science

- **DOE and United Kingdom's Department of Energy and Climate Change**
  - Scientific and technological cooperation in fossil energy technology, particularly activities related to research, development, and demonstration
  - Activities focused on advanced materials and virtual plant simulation

CCS-Related R&D Collaboration

FutureGen

Carbon Sequestration Leadership Forum

Global CCS Institute

International Energy Agency

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