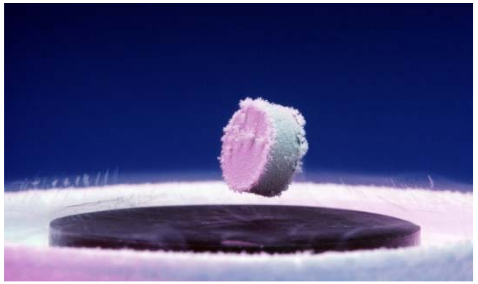



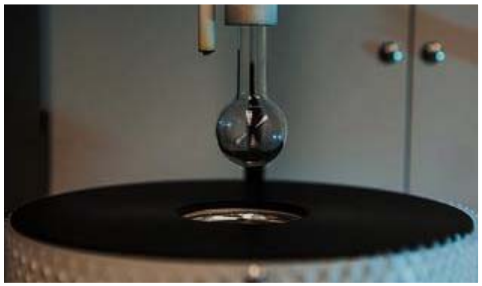
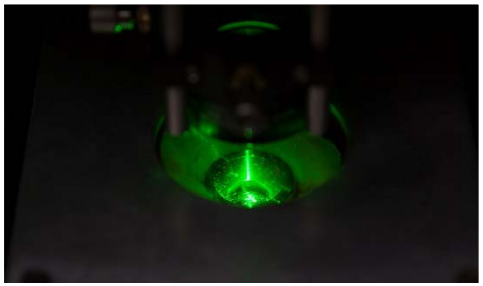
Crosscutting Technology Research

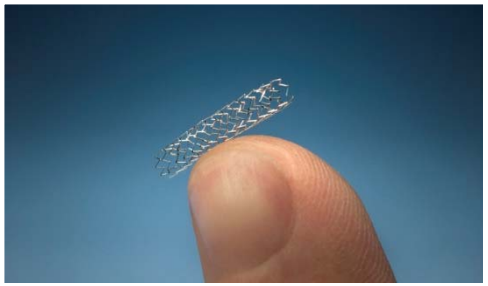
Sean I. Plasynski, Ph.D.

Director, Strategic Center for Coal

April 27, 2015

U.S. DEPARTMENT OF ENERGY | National Energy Technology Laboratory

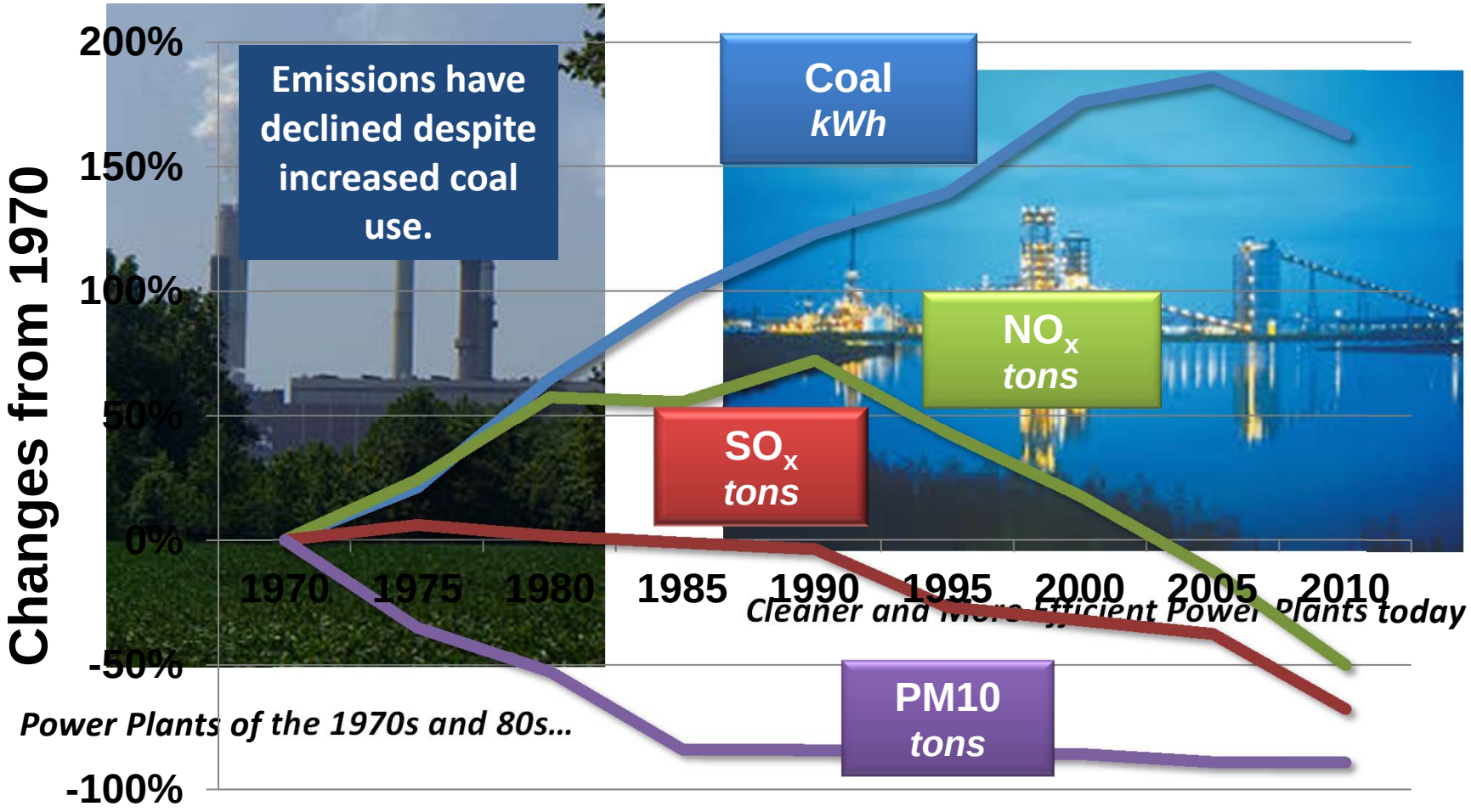





Importance of Research and Technology Development

Pittsburgh as seen from Mt. Washington

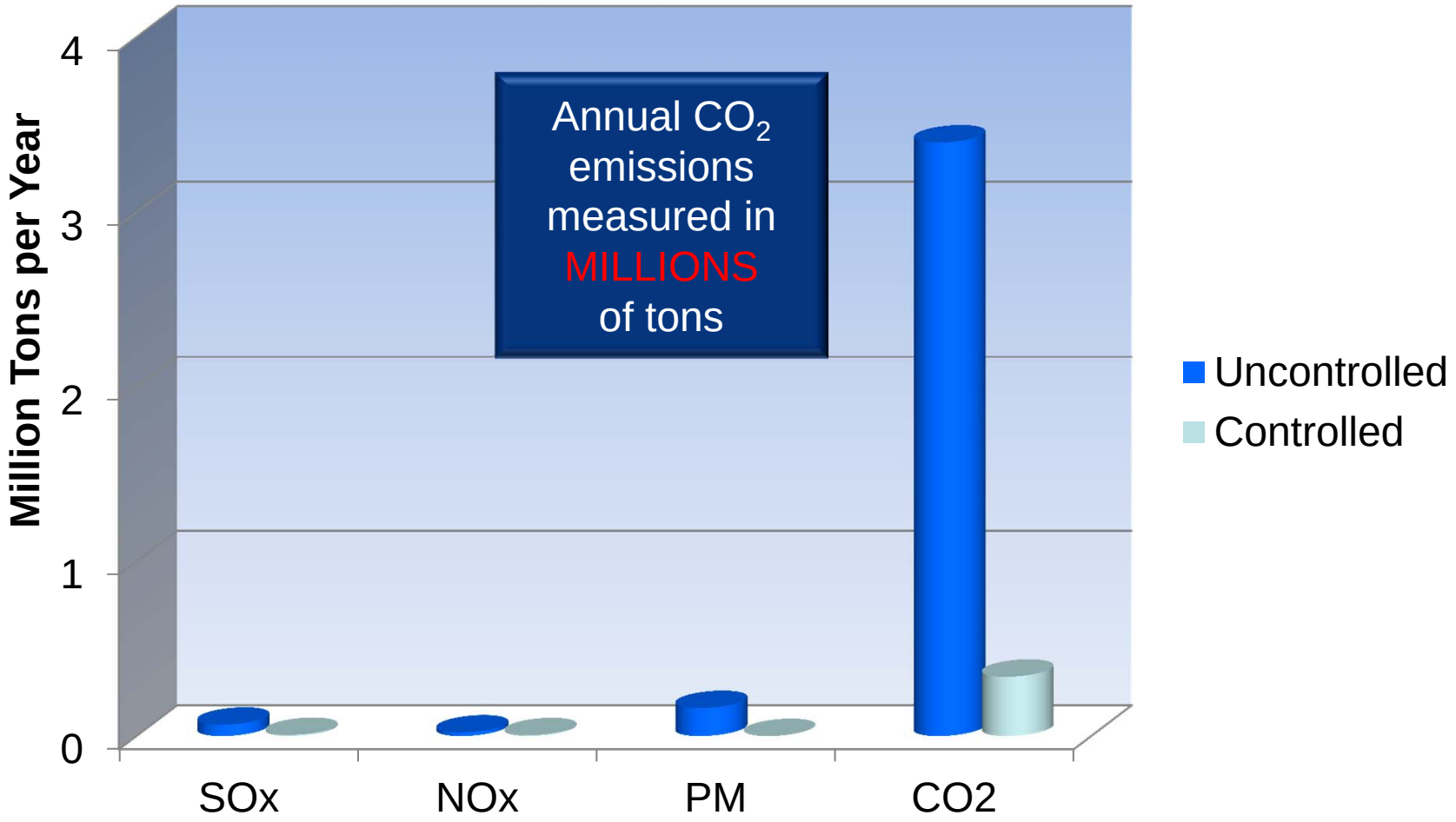
Coal Power Plants with Similar Story



NETL/FE RD&D has History of Success Assisting Coal Power Sector to Meet Environmental Challenges

Still more work ….of larger magnitude

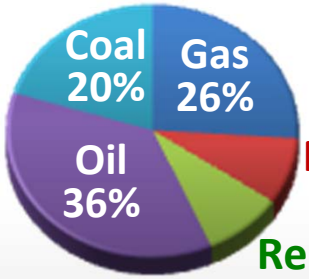
Annual Emissions from a Typical 500-MW Coal Plant



Source: Steam 40th Edition, Babcock & Wilcox 1992, page 32-2

Energy Demand 2011

97 QBtu / Year
82% Fossil Energy

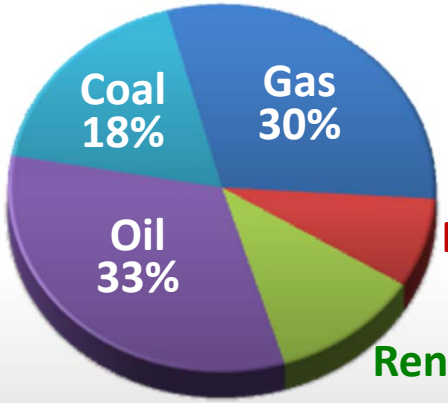


5,498 mmt CO_2

+ 7%
United States

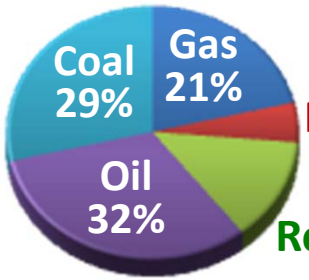
Energy Demand 2035

104 QBtu / Year
81% Fossil Energy



5,546 mmt CO_2

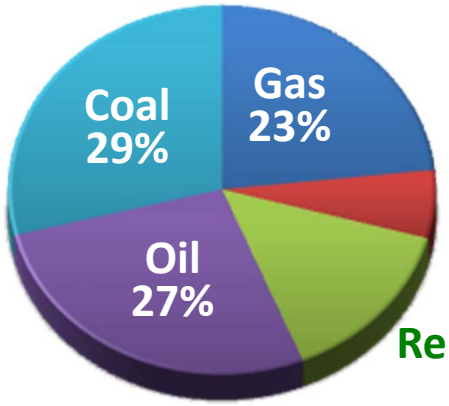
519 QBtu / Year
82% Fossil Energy



31,162 mmt CO_2

+ 43%
World

740 QBtu / Year
80% Fossil Energy



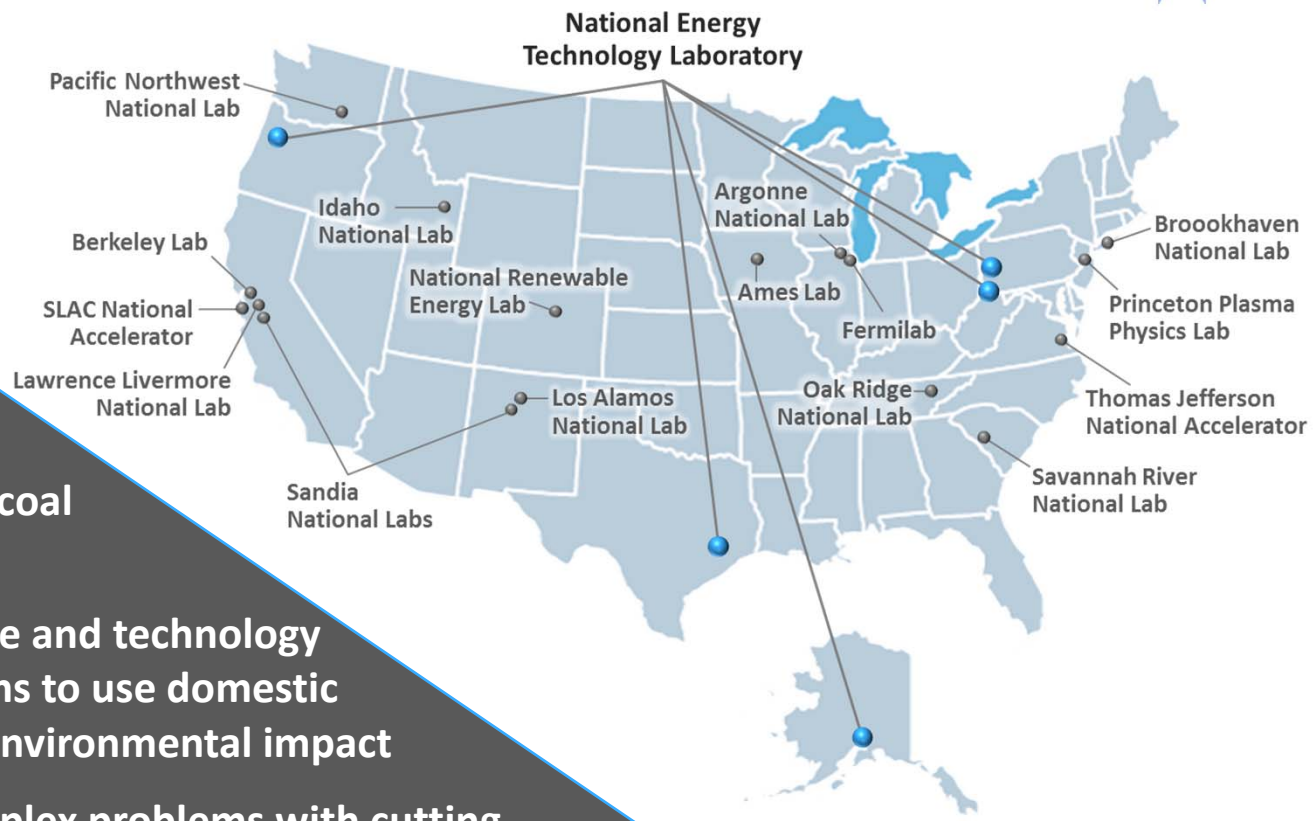
43,111 mmt CO_2

U.S. data from EIA, Annual Energy Outlook 2014; World data from IEA, World Energy Outlook 2013

NETL Mission

Advance energy options to fuel our economy, strengthen our security, and improve our environment

National Energy Technology Laboratory

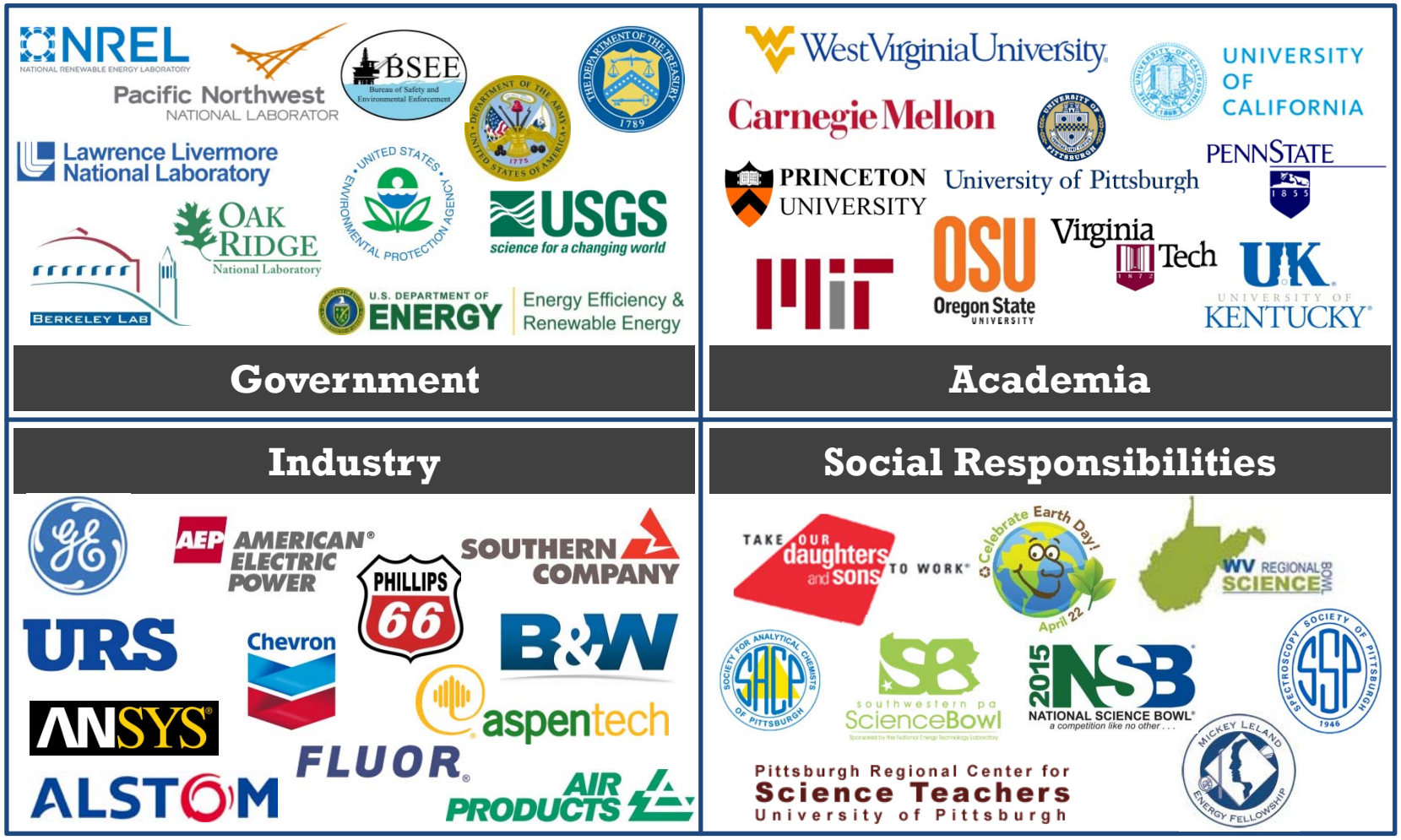


- Partner in DOE's national laboratory system
- Five key laboratories, located in regions rich in coal oil, and natural gas
- Developing critical science and technology to advance energy systems to use domestic resources with minimal environmental impact
- Dedicated to solving complex problems with cutting-edge research & development and technical expertise
- The Nation's only laboratory focused on fossil energy
- The only government-owned, government-operated DOE national lab

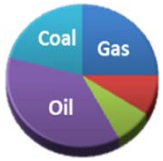
U.S. DEPARTMENT OF ENERGY | Fossil Energy

Collaborations and Partnerships

Key to Successes and Innovative Solutions



NETL's Technical Portfolio

 **Fossil Energy Research**	• *Computational science & engineering* • *Materials science & engineering* • *Energy system dynamics* • *Geological & environmental sciences*
 **Coal**	• *Carbon capture and storage* • *Advanced energy systems* • *Crosscutting technology, e.g., materials, sensors, simulation*
 **Oil & Natural Gas**	• *Unconventional oil & gas* • *Offshore* • *CO_2 enhanced oil recovery* • *Methane hydrates* • *Natural gas infrastructure*
 **Energy Project Management**	• *Vehicle technologies* • *Solid state lighting* • *Grid technology & integration* • *Geothermal*
 **Energy Planning & Analysis**	• *Strategic planning* • *Fossil energy industry analysis* • *Environmental life cycle analysis* • *Novel energy system evaluation* • *Energy reliability assessment*

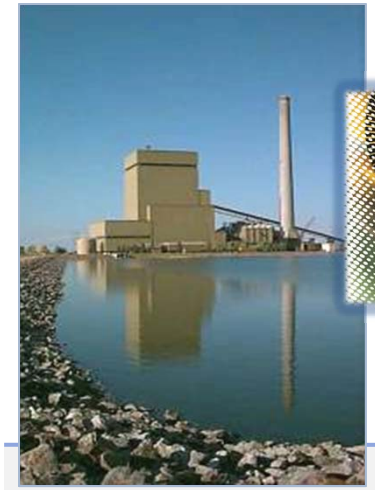
Strategic Center for Coal

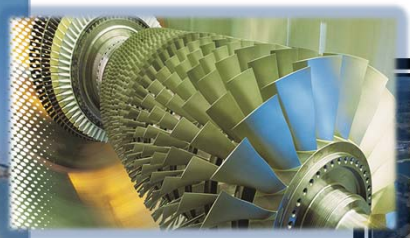
Developing technology options to enable the continued use of America's (and the world's) secure, abundant and affordable coal resources by:

- S
  r
  (
- I
  t
  b
  r al impacts.

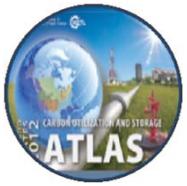
R&D of materials, instrumentation, sensors and controls, modeling and simulation, innovative power cycles, university training and research (UCR/HBCU/OMI)…..

Crosscutting Technology required to support these efforts



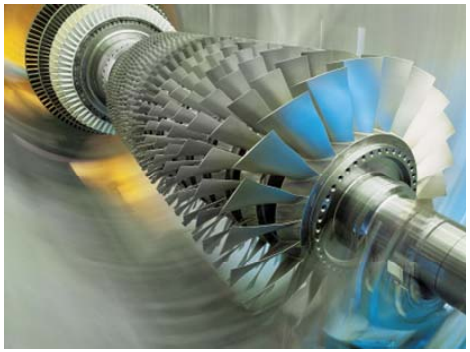


Coal R&D Focus Areas

 **Carbon Capture**	***Developing post-combustion and pre-combustion CO_2 capture technologies for new and existing power plants that reduce capital and operating costs and parasitic energy loads.***
 **Carbon Storage**	***Advancing safe, cost-effective, permanent geologic storage of CO_2 by developing tools to increase understanding of geologic reservoirs and CO_2 behavior in the subsurface.***
 **Advanced Energy Systems**	***Developing a new generation of highly-efficient clean coal power systems capable of producing lower-cost electricity while significantly reducing CO_2 emissions.***
 **Crosscutting Technology**	***Fostering the R&D of materials, instrumentation, sensors, and controls targeted at enhancing the availability and reducing the costs of advanced power systems. Developing computation, simulation, and modeling tools to shorten development timelines and optimize design.***

Integrated Solutions Essential to Meet Goals

Advanced Energy Systems



- Combustion (oxy, PGC)
- Gasification
- Turbines
- Fuel Cells
- Chemical Looping
- SCO2 Power Cycles

Advanced CO_2 Capture

- Solvents
- Sorbents
- Membranes
- Hybrids
- Cryogenic Capture
- CO_2 Compression
- Process Improvements

- ***COE reduced 20–30%***
- ***CO_2 capture cost reduced from $60 to <$40/tonne***
- ***Near-zero GHGs***
- ***Near-zero criteria pollutants***
- ***Minimal water usage***

CO_2 Storage

- Geologic Characterization
- Risk Assessment
- Injection Tests
- MVA
- CO_2 Use (e.g., EOR)

Crosscutting Research

- Materials
- Sensors/Controls
- Computational Tools
- Water Management
- Novel Concepts (DPE, REE)

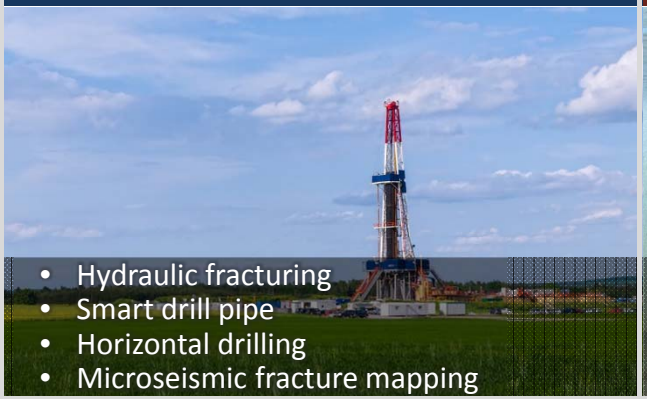
Improvements in Cost and Efficiency Needed for both Base Power Plant and Carbon Capture System

Looking for Future Successes to Match Previous Major Contributions & Outcomes

37 million tons of avoided SO_2 emissions[1]

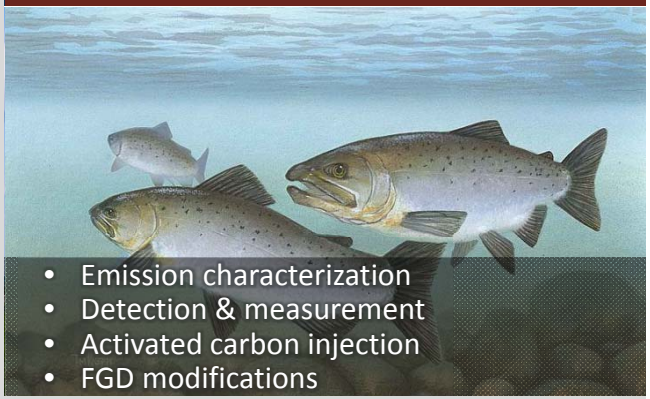
- Flue gas desulfurization (FGD)
- Fluidized bed combustion
- Improved process controls

40-fold increase in shale gas production since 1990[2]



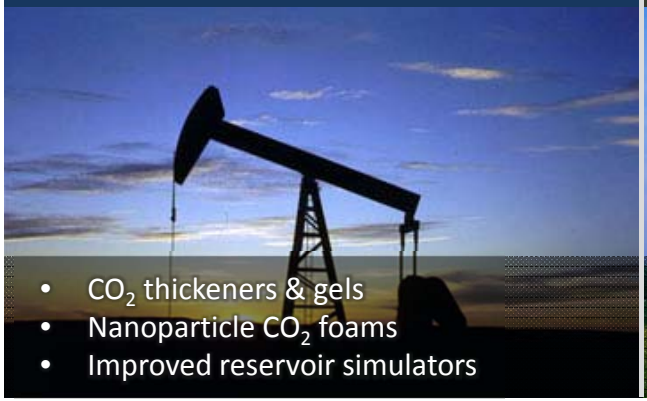
- Hydraulic fracturing
- Smart drill pipe
- Horizontal drilling
- Microseismic fracture mapping

50–75% cost reduction in mercury control at coal-fired power plants[4]



- Emission characterization
- Detection & measurement
- Activated carbon injection
- FGD modifications

10-fold increase in CO_2 enhanced oil recovery since 1980[3]



- CO_2 thickeners & gels
- Nanoparticle CO_2 foams
- Improved reservoir simulators

16 million tons of avoided NO_x emissions[1]

- Low-NOx burners
- Turbine developments
- Selective catalytic reduction
- Non-selective catalytic reduction

$13 return for every $1 invested[1]

[1]Bezdek, R., Wendling, R., The Return on Investment of the Clean Coal Technology Program in the USA. Energy Policy, Vol. 54, 03/2013, pp. 104–112. [2]DOE EIA Annual Energy Outlook 2013, Fig. 91. [3]Oil & Gas Journal, 04/05/1982, Annual Production Report, p. 140; Oil & Gas Journal, 04/23/1990, Annual Production Report, p. 52; Oil & Gas Journal, 03/20/2000, 2000 Worldwide EOR Survey, p. 42. [4]Feeley, T., Jones, A., Brickett, L., et al., An Update on DOE's Phase II and Phase III Mercury Control Technology R&D Program. Fuel Processing Technology, Vol. 90, 11/2009, pp. 1389–1391.

It's All About a Clean, Affordable Energy Future




For More Information, Contact NETL

the ENERGY lab

Delivering Yesterday and Preparing for Tomorrow