



*Solutions for Today ♦ Options for Tomorrow*



## **Backbone of the Energy Future**

*2015 International Pittsburgh Coal Conference  
October 6, 2015*

**Grace M. Bochenek, Ph.D.**

Director



U.S. DEPARTMENT OF  
**ENERGY**

National Energy  
Technology Laboratory

# Global Drivers



FOOD



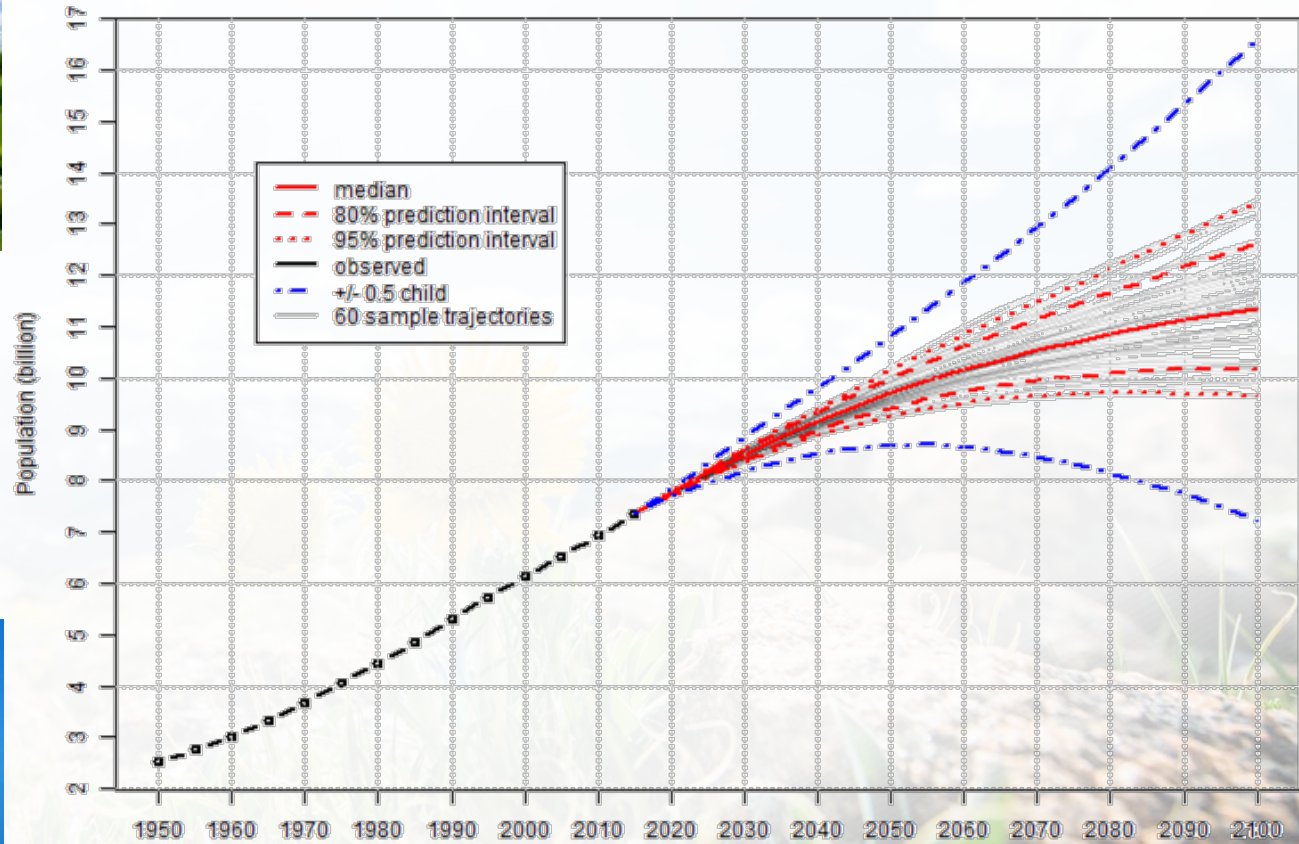
ENERGY



WATER



## World Population



Source: United Nations, Department of Economic and Social Affairs, Population Division (2015).  
*World Population Prospects: The 2015 Revision*. <http://esa.un.org/unpd/wpp/>



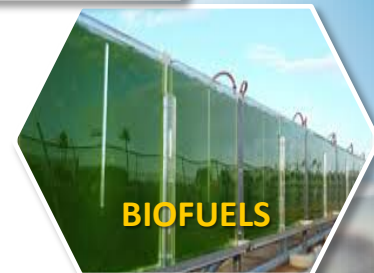
# “All of the Above” Energy Future



***Carbon Capture & Sequestration***



***Safe & Responsible Domestic Oil & Gas Production***



***Advancing Clean Energy***



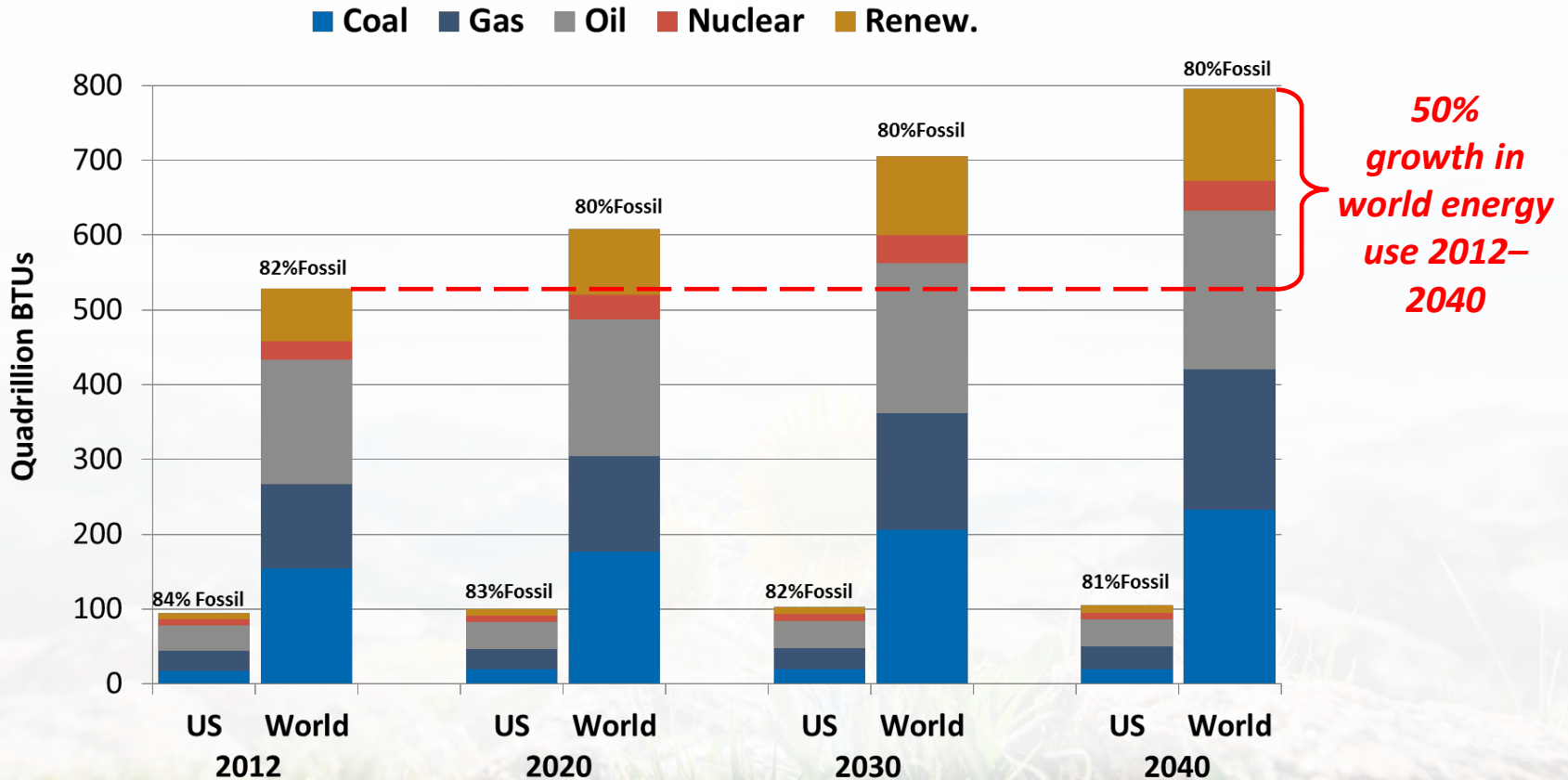
***Advancing Energy Efficiency***



***Developing Clean Fuels***

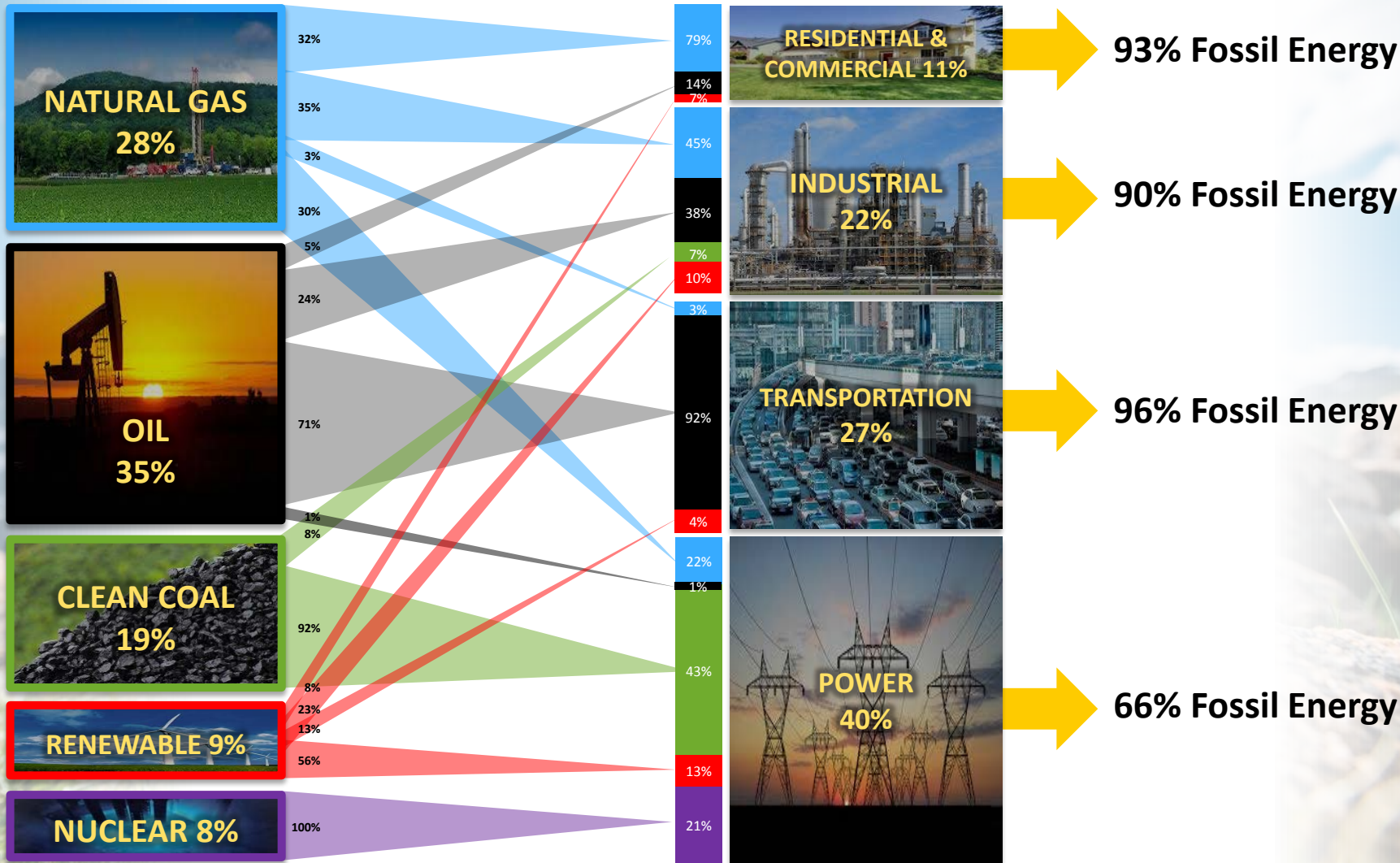


# The World and U.S. Energy Future



***≥80% Fossil Energy Today AND Tomorrow  
Dominated by Global Growth***

# Delivering To All Domestic Sectors





# "All of the Above" Carbon Management Strategy

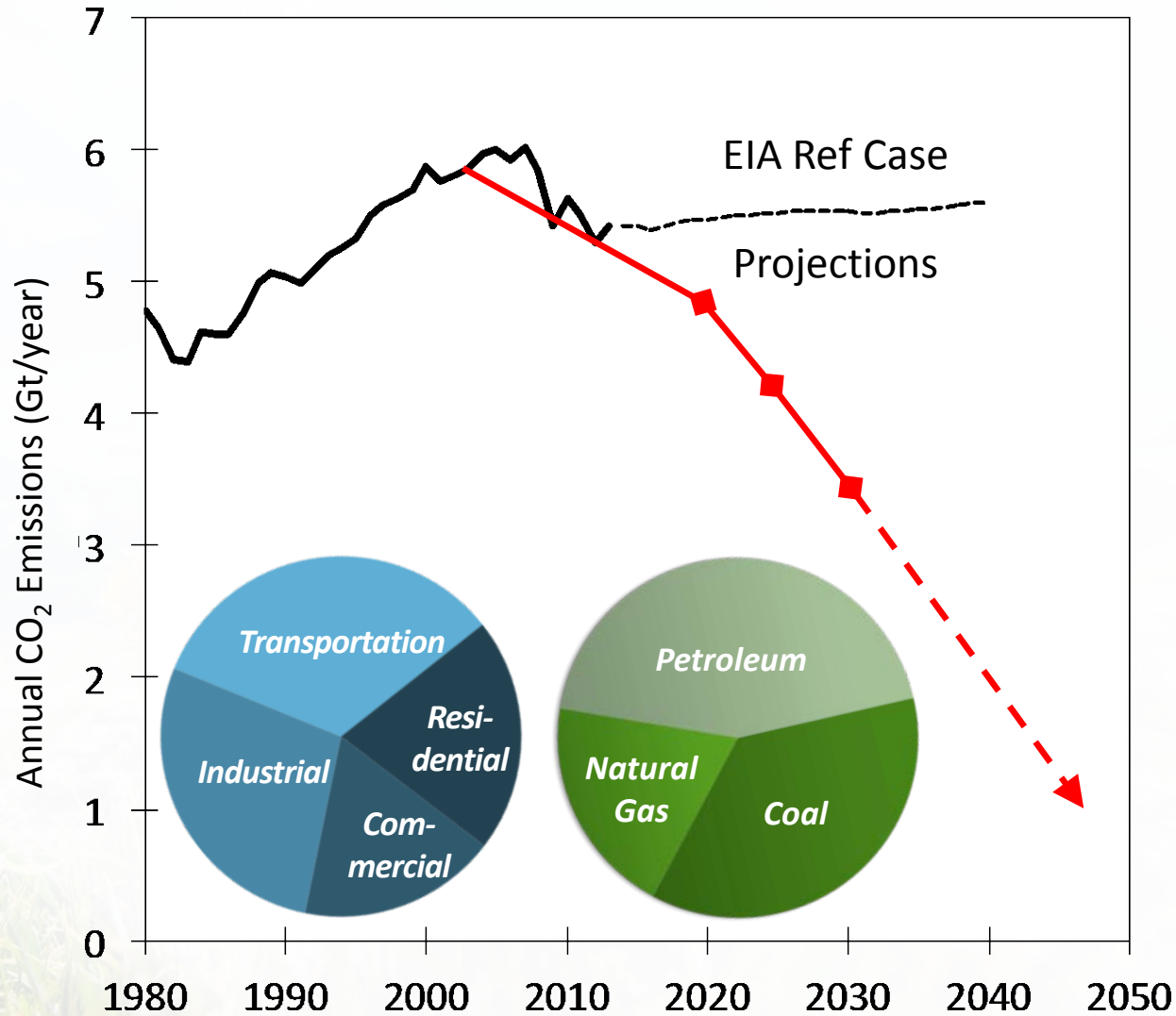


**Increase  
Energy Efficiency**

**Reduce Carbon  
Emissions**

**All Sectors, All Fuels**

**Lead Global Efforts**



# Enduring Mission Elements



*Coal*



*Petroleum*



*Faster  
Cheaper  
Safer*



*Natural Gas*



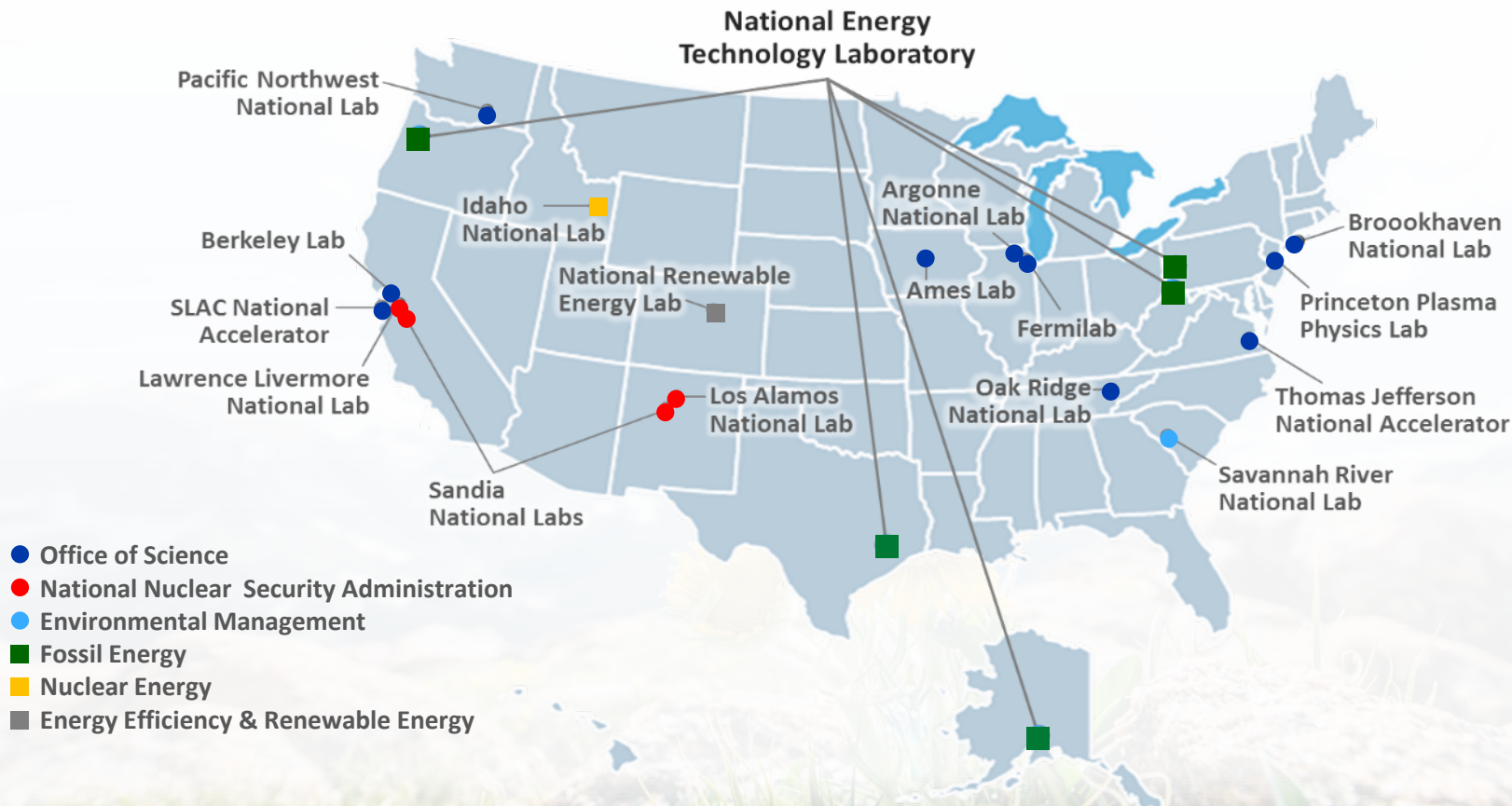
*Hydrates*

*Effective  
Resource  
Development*

*Efficient Energy  
Conversion*

*Environmental  
Sustainability*

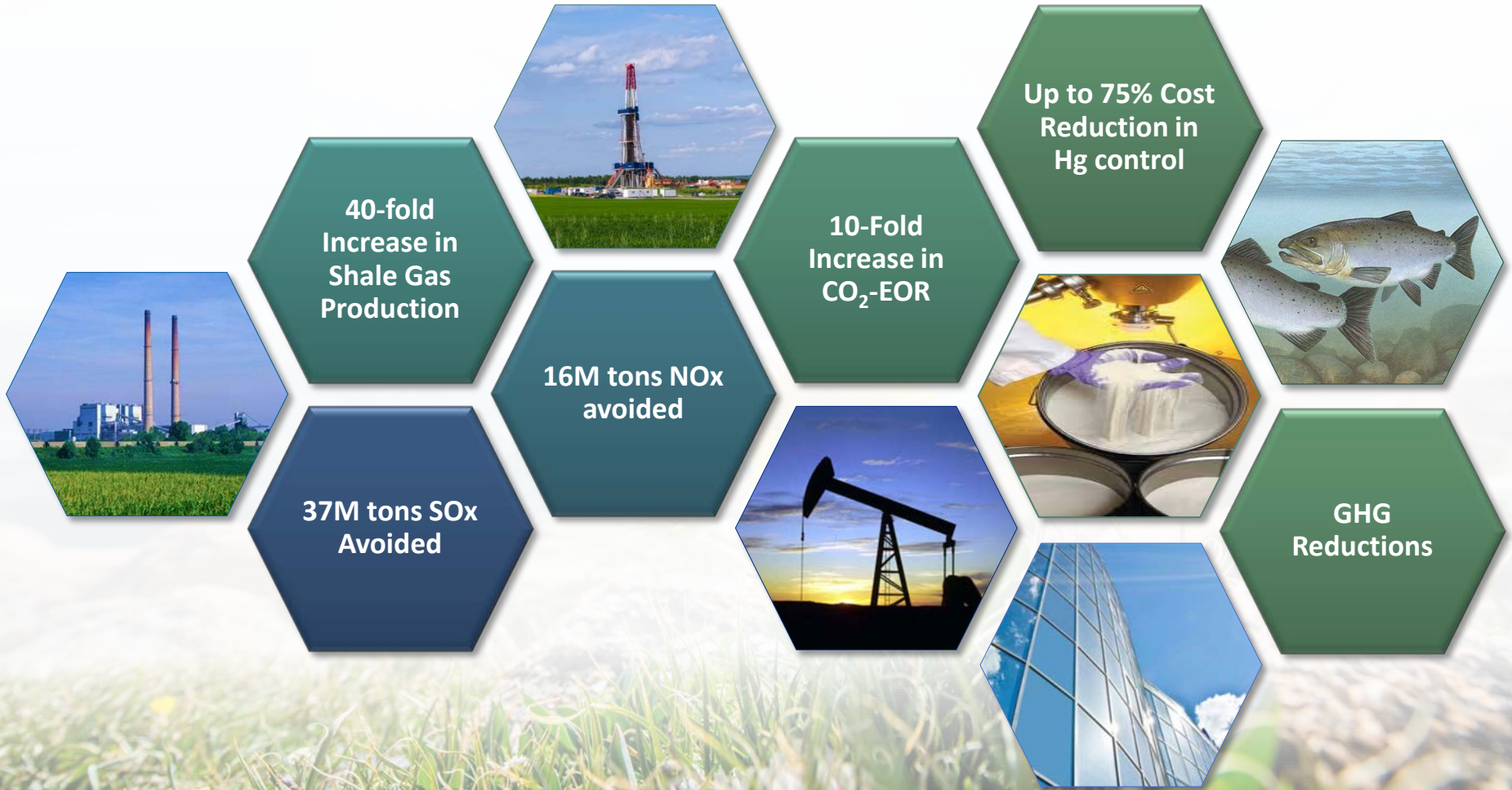
# NETL: THE Fossil Energy Laboratory



***NETL's mission is to discover, integrate, and mature technology solutions to enhance the Nation's energy foundation and protect the environment for future generations***



# History of Enabling Fossil Fuels



# Technology Readiness...Maturing Technology



EXTRAMURAL

INTRAMURAL & EXTRAMURAL



Technology Demonstration  
TRL 8-9



Process Engineering  
& Integration  
TRL 5-7



Applied Research  
TRL 2-4

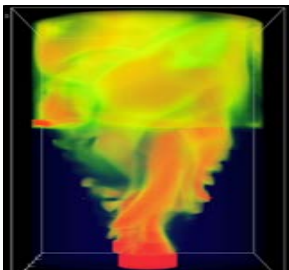
*Energy Solutions  
for Today*

*Energy Options  
for Tomorrow*

TRL=Technology Readiness Level



# Enduring Core Competencies



## Computational Engineering

High Performance Computer

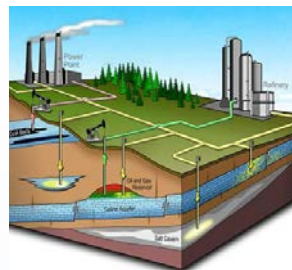
Codes & Data Management



## Materials Engineering

Structural & Functional

Design, Synthesis & Performance



## Environmental Engineering

Air, Water & Geology

Understanding & Mitigation



## Energy Conversion

Component & Device

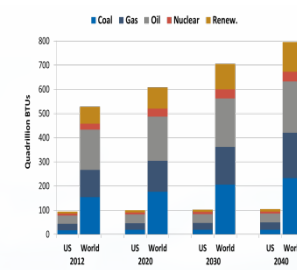
Design & Validation



## System Engineering

Process & System

Optimization, Validation & Economics



## Markets & Benefits

Technology & Resources

Assessment & Projections

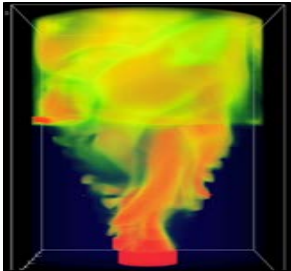
***Effective Resource Development***

***Efficient Energy Conversion***

***Environmental Sustainability***



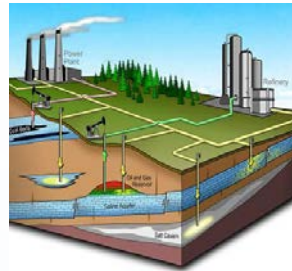
# Core Competencies & Technical Thrusts



**Computational Engineering**



**Materials Engineering**



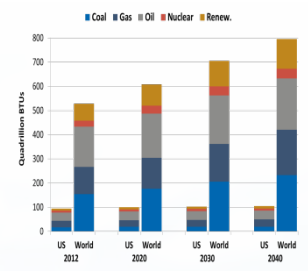
**Environmental Engineering**



**Energy Conversion**



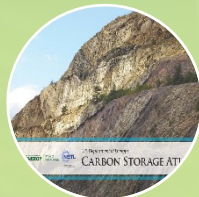
**System Engineering**



**Markets & Benefits**



**Carbon Storage**



**Carbon Capture**



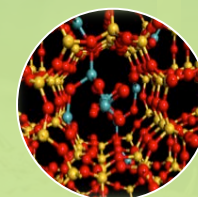
**Sensors**



**Advanced Materials**



**Advanced Computing**



**Advanced Energy Systems**



**Enhanced Resource Production**



**Environmentally Prudent Development**



**Transmission & Delivery**



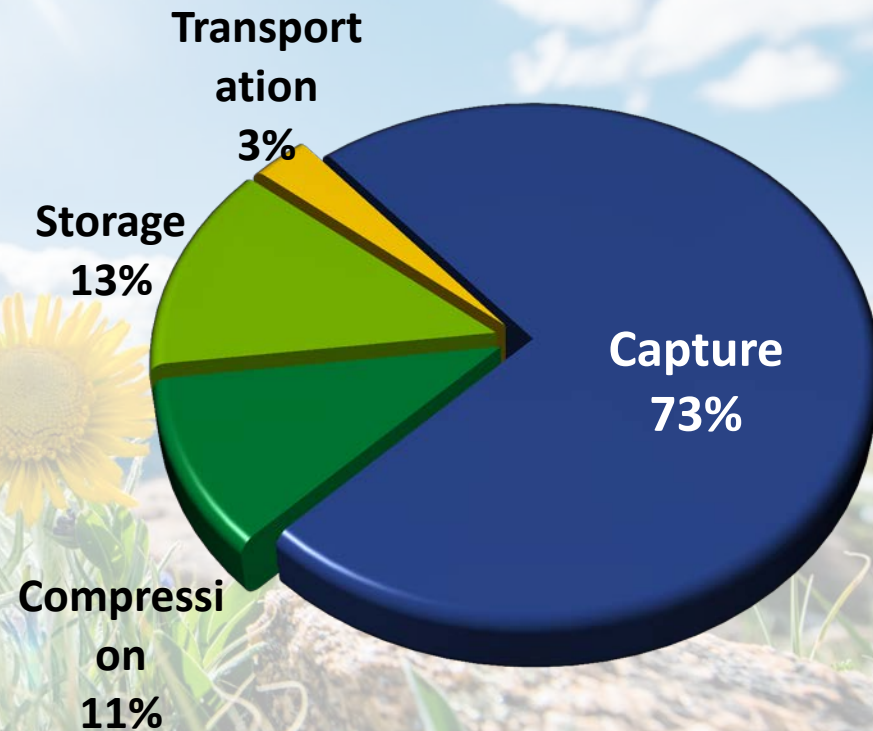
**Methane Hydrates**



# Carbon Capture Challenges



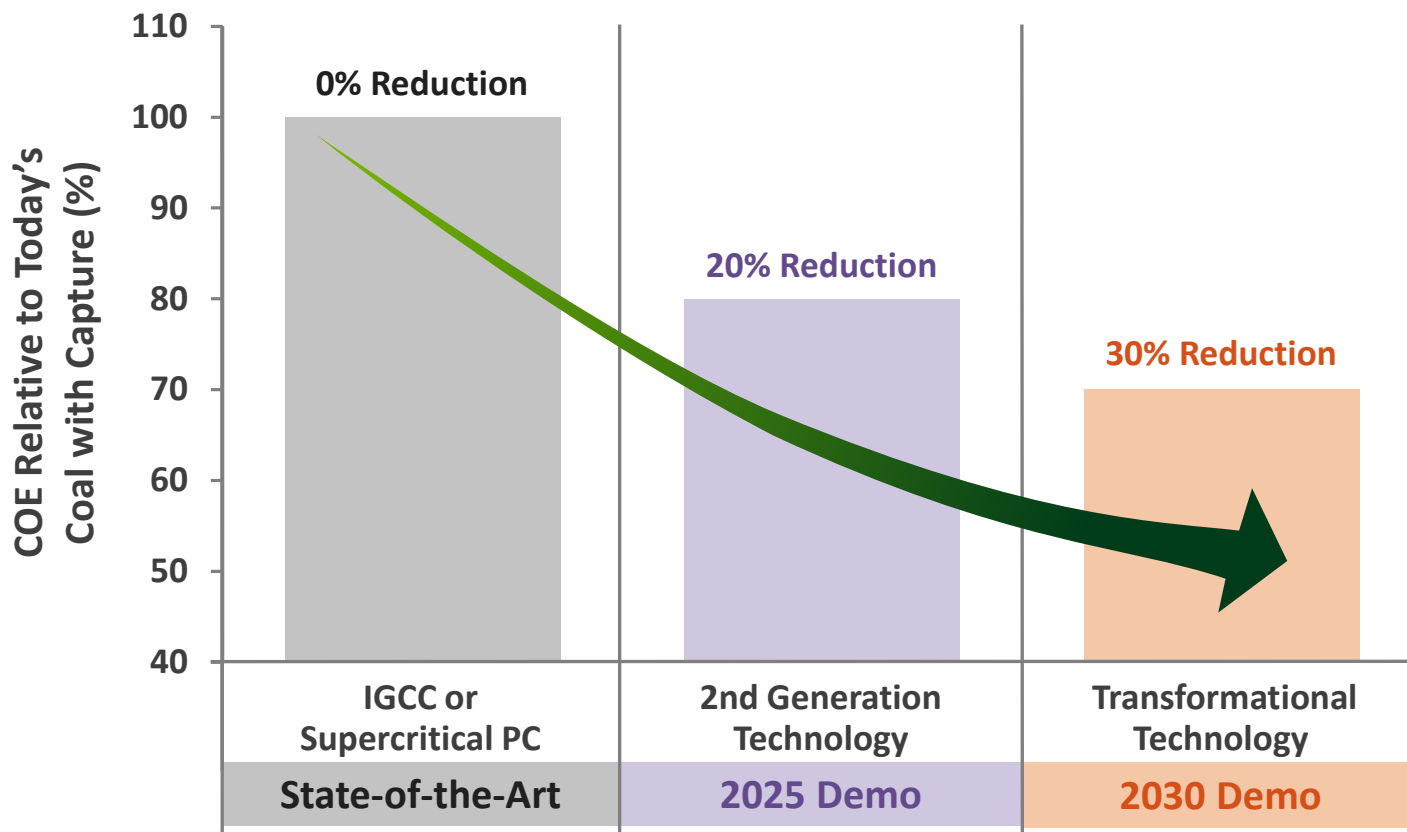
- **Cost Effectiveness**
- **System Integration**
- **Scale-up**
- **Supply Chain**
- **Thermodynamics**
- **Parasitic Load**
- **CO<sub>2</sub> Compression**
- **Flue Gas Contamination**
- **Water Use**



# Driving Down the COE with CCS



## Cost of Electricity (COE) Reduction Targets



Goals are for greenfield plants. Costs are nth-of-a-kind and include compression to 2215 psia, but exclude CO<sub>2</sub> transport and storage costs.



# Changing the Paradigm



## TRADITIONAL TIME TO DEPLOY NEW TECHNOLOGY IN THE POWER INDUSTRY

Laboratory Development  
10–15 years

Process Scale Up  
20–30 years

1 kWe

1 MWe

10 MWe

100 MWe

500 MWe

## ACCELERATED DEPLOYMENT TIMELINE

Process Scale Up  
15 years

1 MWe

10 MWe

100 MWe

500 MWe



CCSI™  
Carbon Capture Simulation Initiative

### National Labs



### Academia

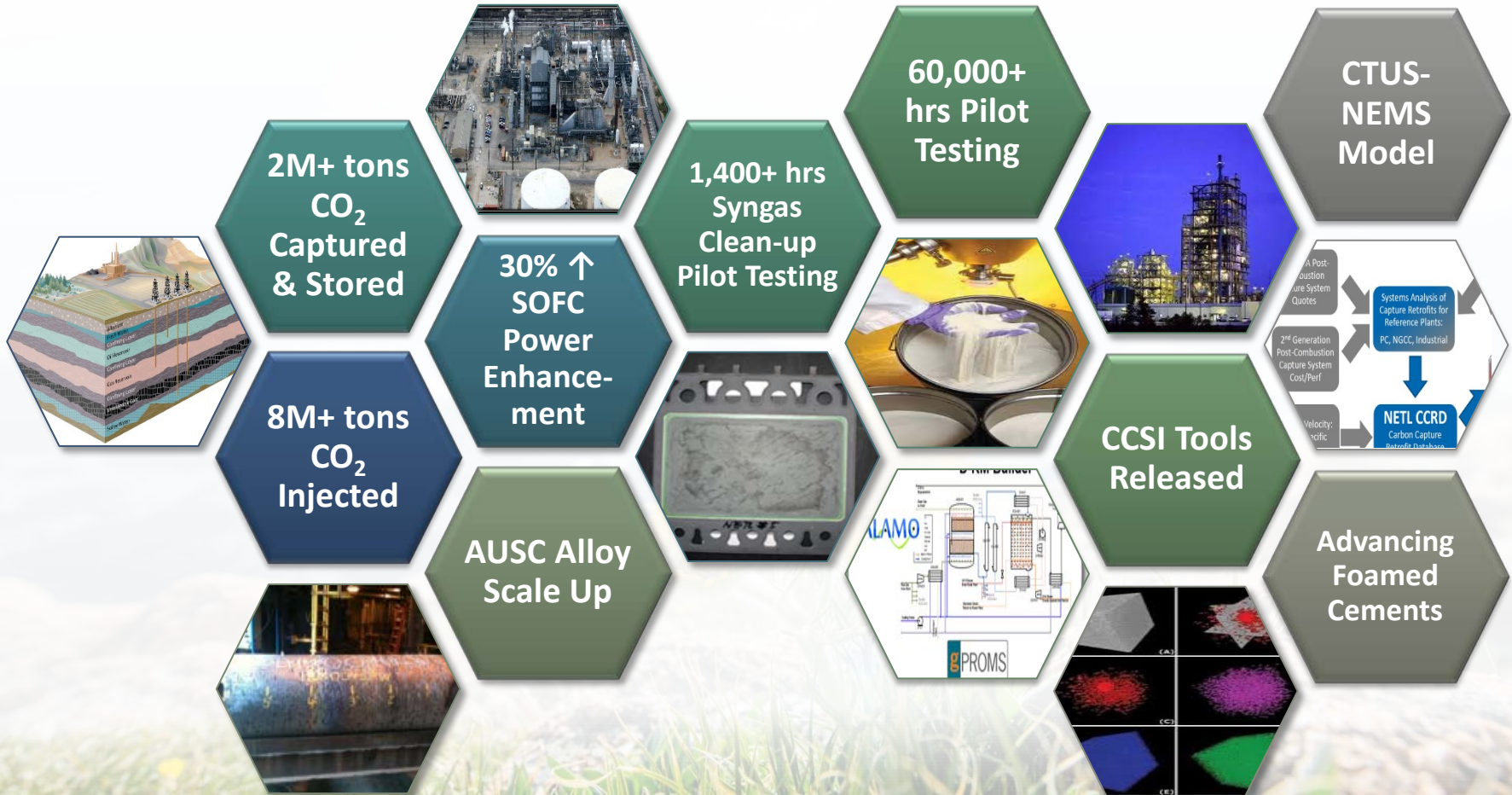


### Industry



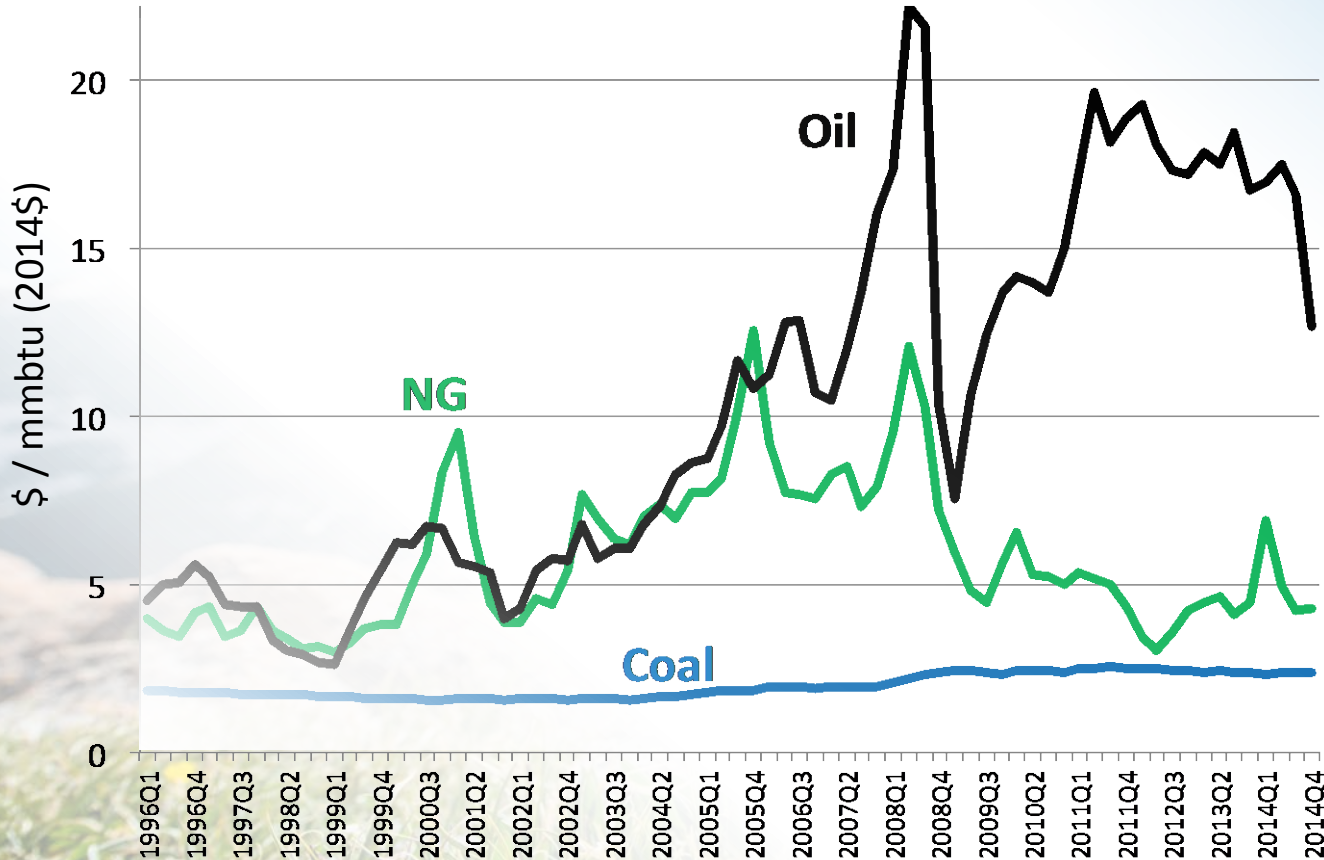
2010    2015    2020    2025    2030    2035    2040    2045    2050

# Advancing FE Solutions



*Understanding ~ Materials ~ Processes ~ Tools ~ Technology*

# It is Our Challenge



*We do not inherit the earth from our ancestors; we borrow it from our children*



# Lets Do This Together



- **Partnering with NETL**

<http://www.netl.doe.gov/research/on-site-research/partnering-with-us>

- **Business Opportunities with NETL**

<http://www.netl.doe.gov/business>

NETL National Energy Technology Laboratory

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U.S. DEPARTMENT OF ENERGY

## ON-SITE RESEARCH

Research

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### A National Energy R&D Resource since 1910

As the lead laboratory for DOE's Office of Fossil Energy, NETL relies on a strong onsite research program conducted by federal scientists and engineers working in partnership with academia, other research institutions, and the private sector. NETL's Office of Research and Development (ORD) provides the science and engineering basis for next generation technologies that will minimize the environmental impact of fossil fuel use and optimize the use of our domestic energy resources and infrastructure.

ORD's Director Presents an Overview of NETL's Onsite Research

#### RESEARCH PORTFOLIO

**RESEARCH PORTFOLIO:** NETL's onsite research portfolio contributes to the U.S. DOE's goals for energy safety, affordability, and national energy security. In addition to the research performed on behalf of the Office of Fossil Energy, in-house researchers are leveraging core competencies to address other research issues of national importance.

Coal | Oil & Gas

#### RESEARCH CAPABILITIES

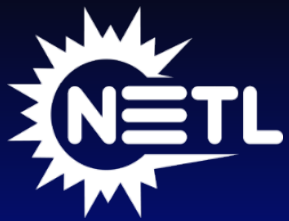
**RESEARCH CAPABILITIES:** NETL combines state-of-the-art research facilities with extensive experience working with fossil resources, creating an award-winning combination. NETL's expert research staff collaborates with well-known research universities, other national laboratories, and industry stakeholders to address and solve barriers to commercialization of new technology for power systems, fuels, and environmental and waste management.

Competencies | Personnel | Facilities | Collaborations

#### RESEARCH INTERSHIPS

**RESEARCH INTERSHIPS:** NETL offers internships to members of the academic community from undergraduates through faculty. The goals are to inspire bright scientists and engineers to tackle challenges in energy research and to stimulate NETL's program with the new ideas, techniques, and approaches to problems that these highly motivated students and faculty bring to bear.

# Solutions for Today....Options for Tomorrow



*For More Information, Contact NETL*

**the ENERGY lab**

*[www.netl.doe.gov](http://www.netl.doe.gov)*

