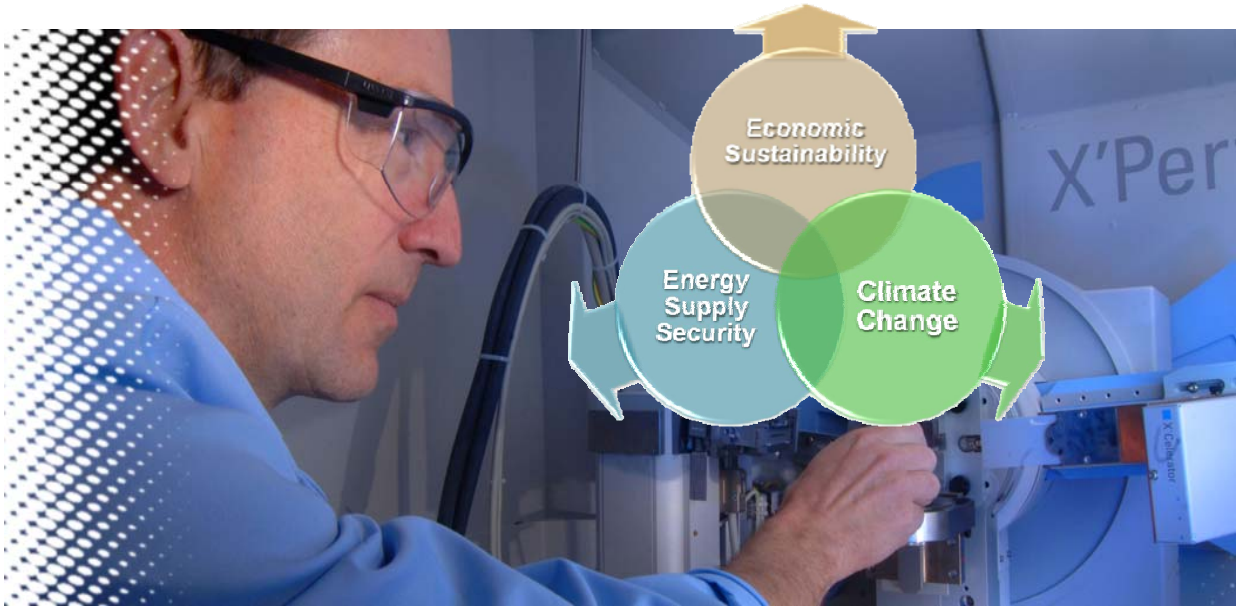
NATIONAL ENERGY TECHNOLOGY LABORATORY



10th Annual

SECA Workshop

Pittsburgh, Pennsylvania

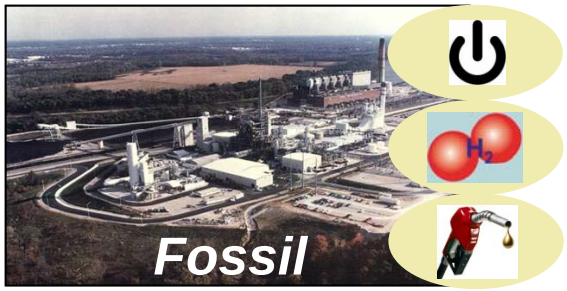
July 14-16, 2009

Advancing Coal Energy Technologies
Department of Energy R&D Program

Scott M. Klara --- Strategic Center for Coal

Office of
Fossil Energy

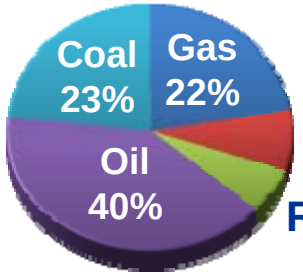
No Single Energy Solution
Diverse Portfolio of Approaches Is Needed

Energy Resources and Products	Barriers to Widespread Deployment
	• Non-proliferation • Long-Term Waste Disposal • Fuel Supply Security • Costs
	• Affordable Large-scale CCS • Need for High Efficiency & Benign Emissions • Mining • Water and Land Use
	• Capital Cost • Intermittency • Sensitive Locations (prairies, deserts, oceans) • Land Use and Trespass/Visibility issues

World's Reliance on Fossil Energy Will Continue

Energy Demand 2006

100 QBtu / Year
85% Fossil Energy



Nuclear
8%

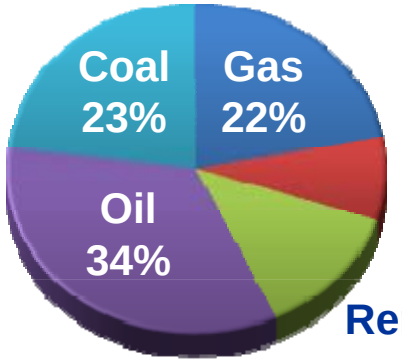
Renewables
7%

+ 13%

United States

Energy Demand 2030

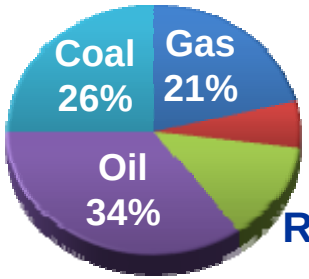
113 QBtu / Year
79% Fossil Energy



Nuclear
8%

Renewables
13%

465 QBtu / Year
81% Fossil Energy



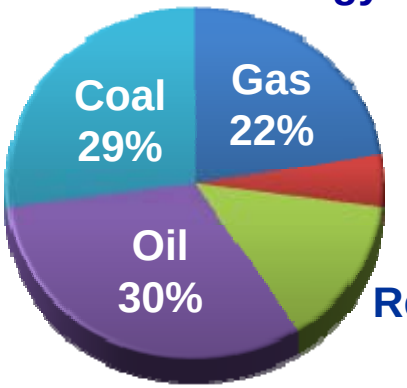
Nuclear
6%

Renewables
13%

+ 45%

World

675 QBtu / Year
81% Fossil Energy

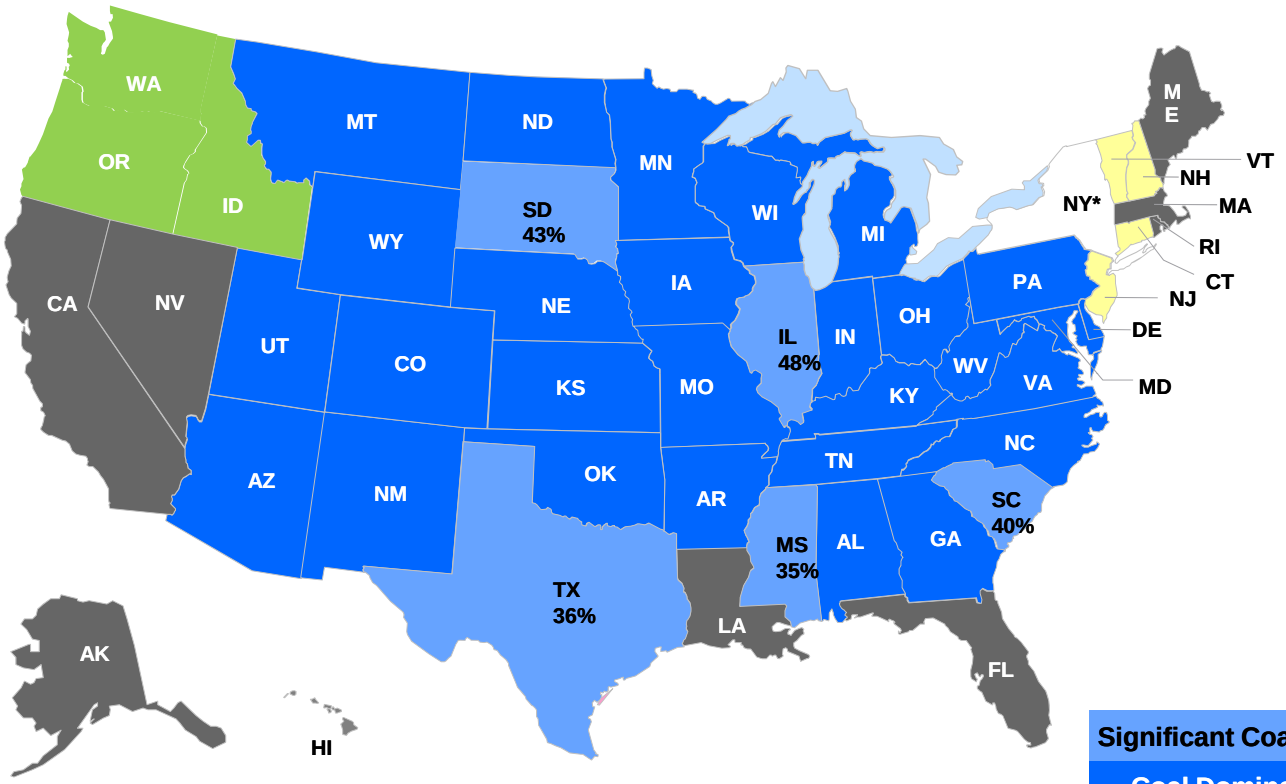


Nuclear
5%

Renewables
14%

U.S. data from EIA, Annual Energy Outlook 2009 early release ; world data from IEA, World Energy Outlook 2008

Significant Coal-Reliance In United States



33 States Have Significant Coal-Reliant Generation

Significant Coal Generation >35%
Coal Dominated Generation
NG Dominated Generation
Nuclear Dominated Generation
Hydro Dominated Generation
Oil Dominated Generation

**** - NY diversified all sources <35% of total***

Source: EIA, share of 2006 in-State electricity production

The Big Technology Issues For Coal

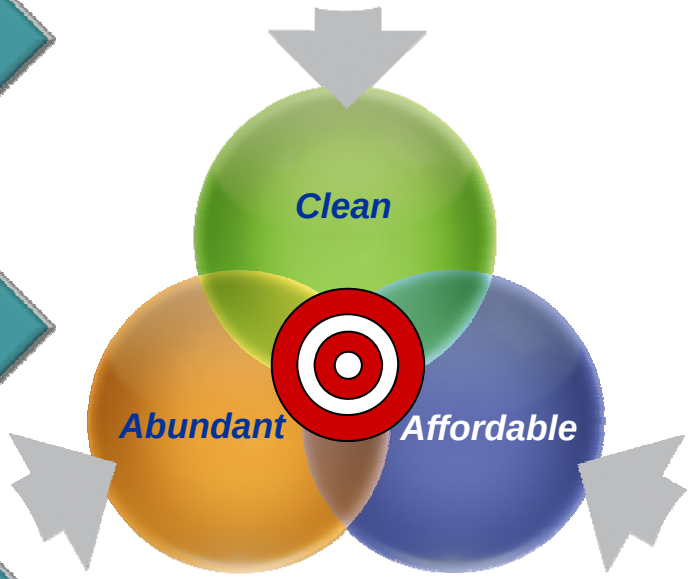
Manage CO_2 Emissions

Reduce Criteria Pollutants

Minimize Water Use

Control Costs

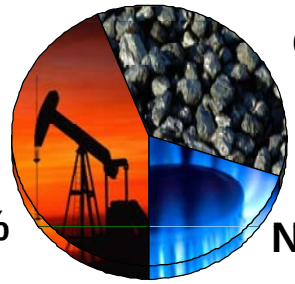
Balanced Solutions



Carbon Management -- Most Critical Issue

Carbon Emissions 2006

5.9 bmt CO_2



Coal 36%

Oil 44%

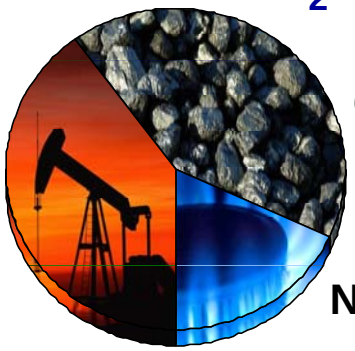
Natural Gas 20%

+8%

United States

Carbon Emissions 2030

6.4 bmt CO_2

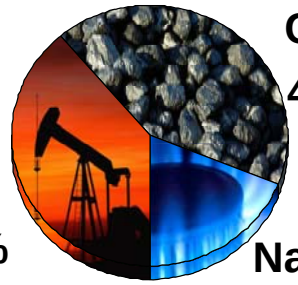


Oil 40%

Coal 39%

Natural Gas 21%

27.9 bmt CO_2



Coal 42%

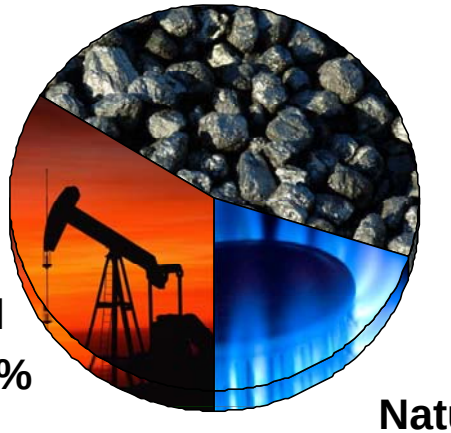
Oil 39%

Natural Gas 19%

+45%

World

40.6 bmt CO_2



Coal 46%

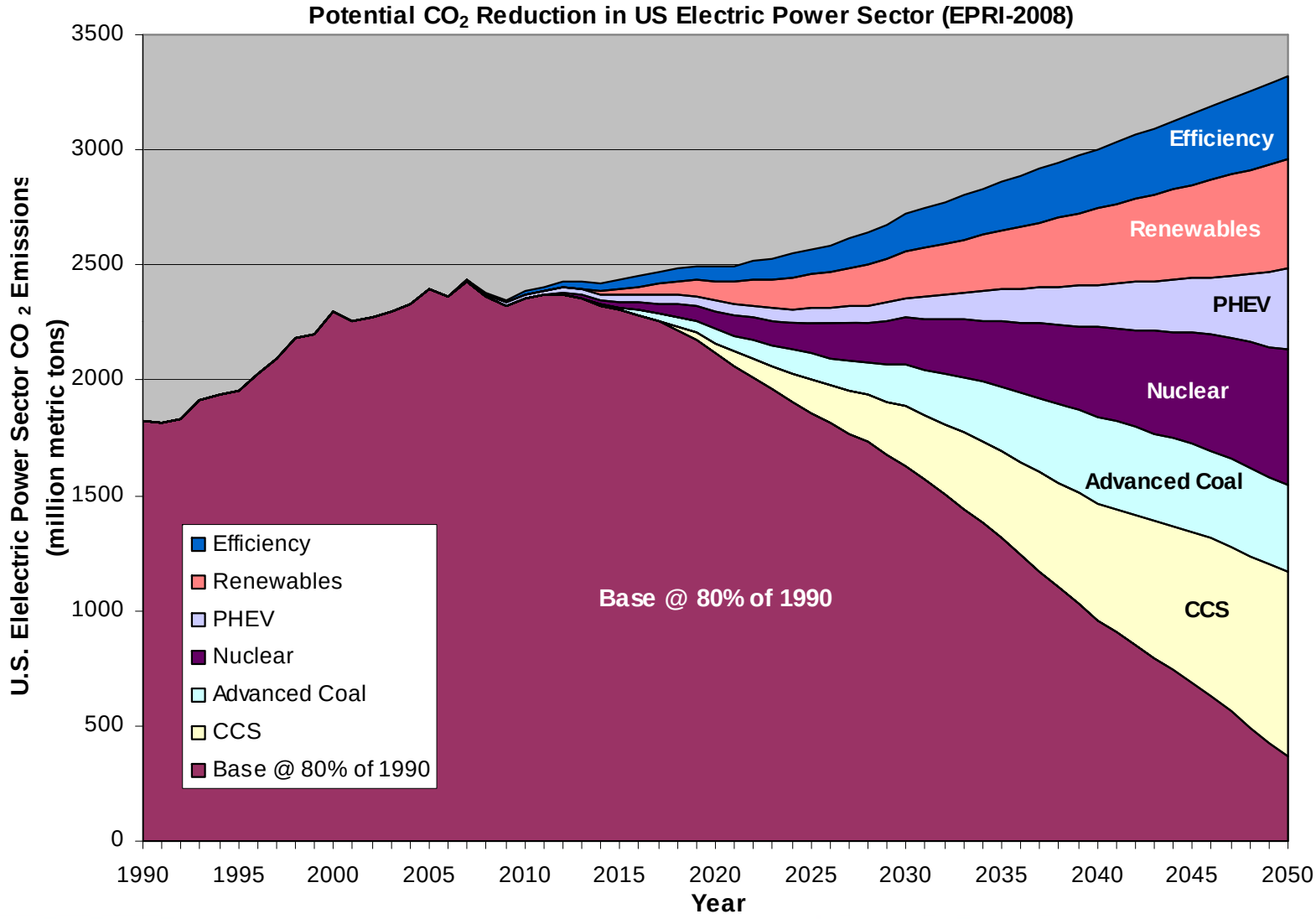
Oil 34%

Natural Gas 20%

bmt – billion metric tonnes

U.S. data from Energy Information Agency, Annual Energy Outlook 2009 early release
World data from International Energy Agency, World Energy Outlook 2008

Advanced Coal Technologies with CCS Will Be Critical to Stabilizing CO_2 Emissions

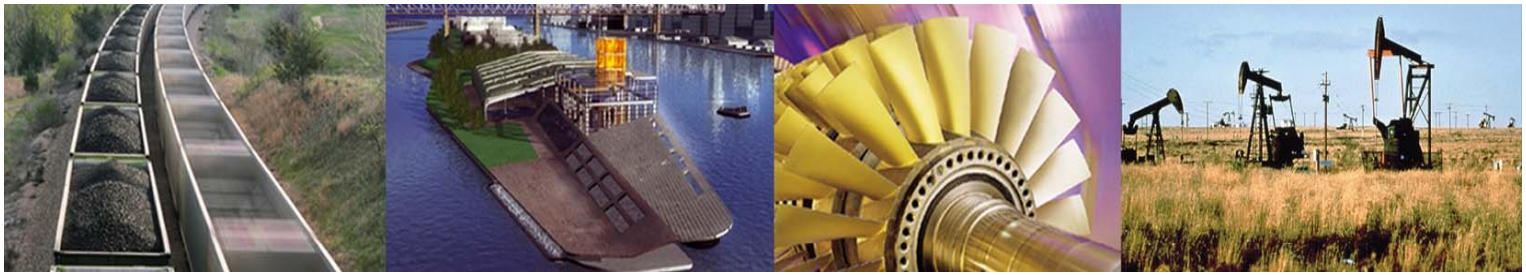


Coal Research & Development

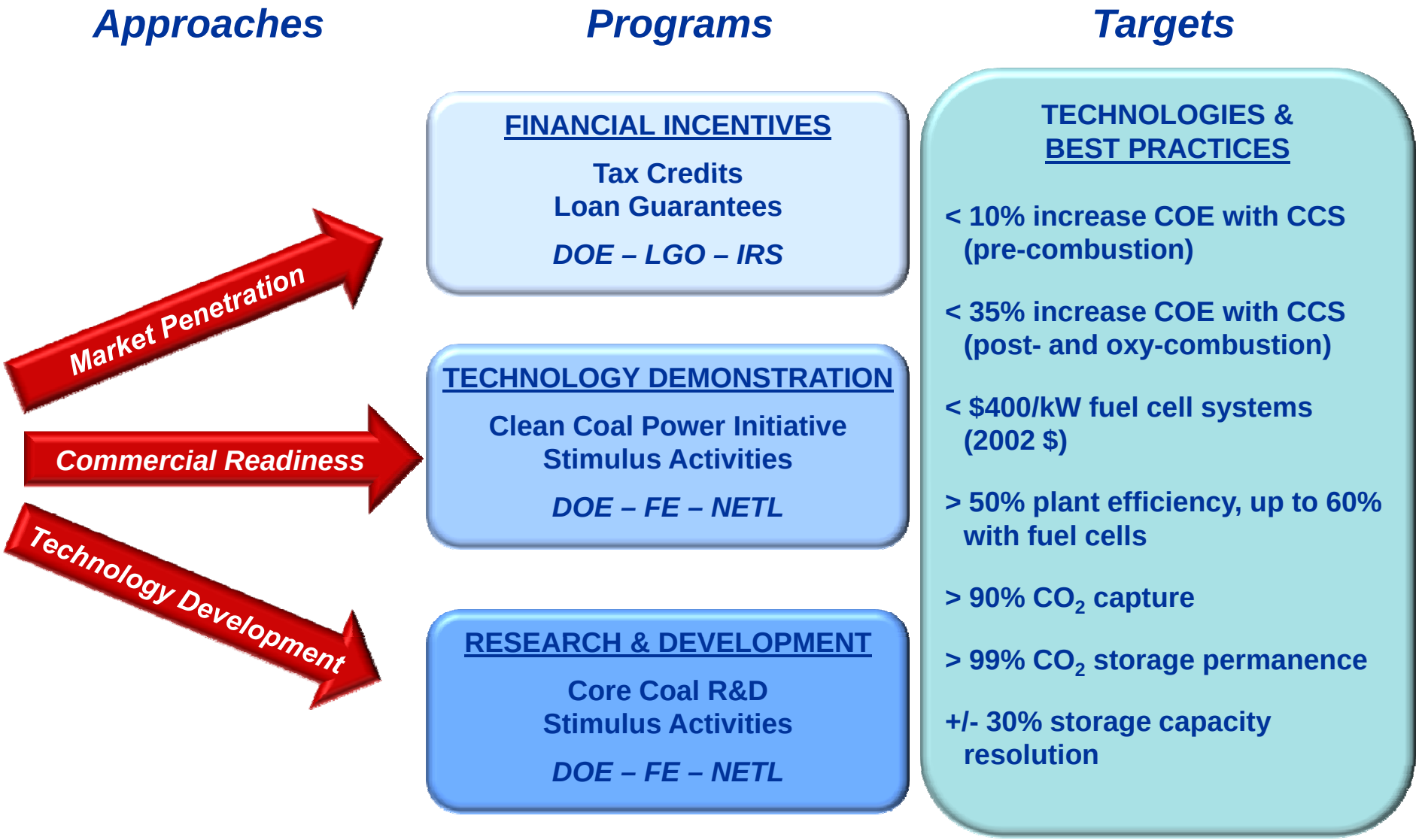
Must Drive Technology

To Negligible Emissions

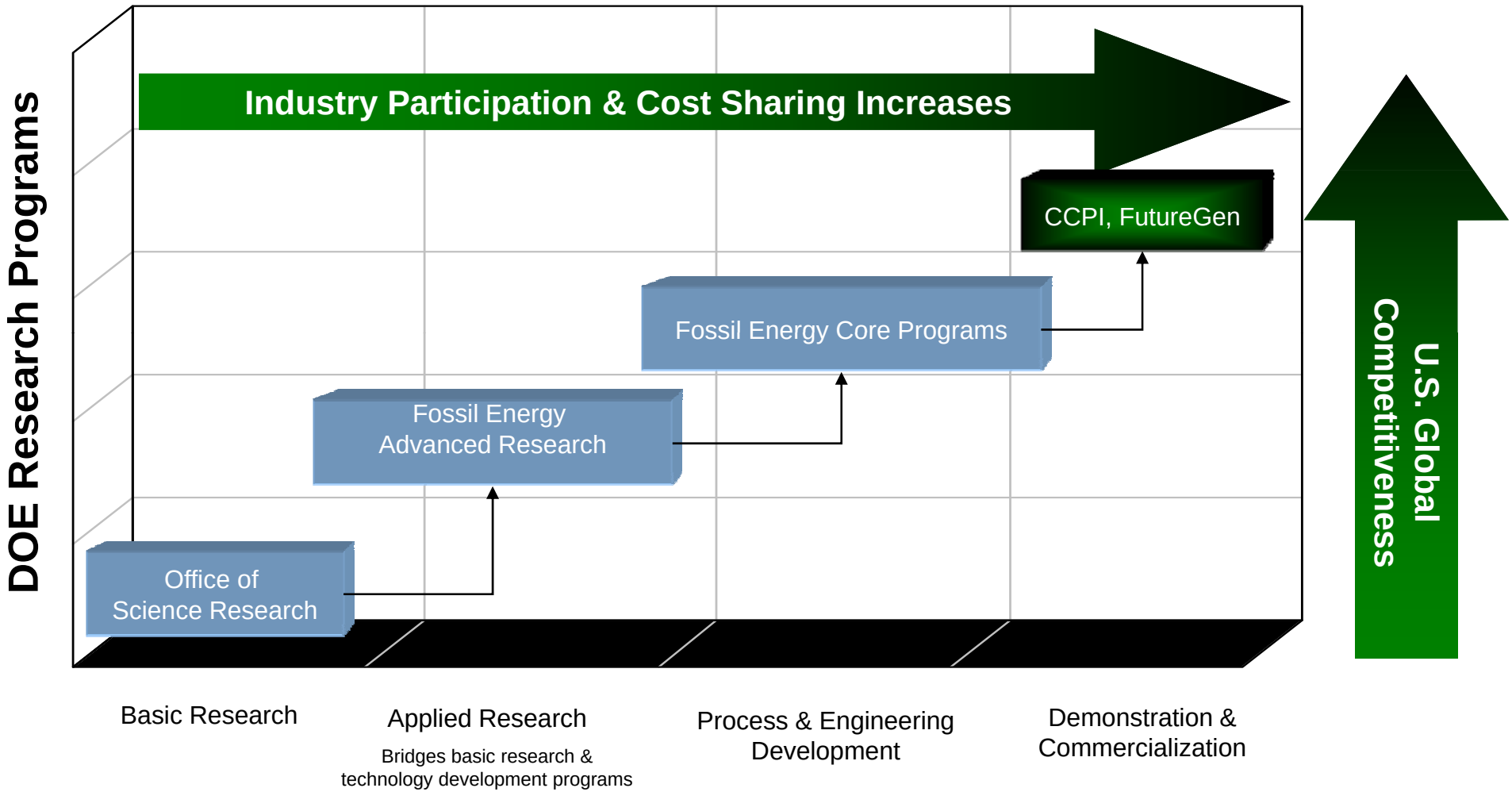
at Reasonable Cost



Coal Federal Research Investment Strategy



Stages of Federal R&D



Primary Technology Focus

Greenhouse Gas Mitigation Thru….

- Increased Efficiency
- Carbon Capture & Storage
- Biomass Co-feeding Offsets

Targets Keep R&D Focused & On Track

- **Deliver technologies & best practices that validate:**
  - < 10% increase in COE with CCS (pre-combustion)
  - < 35% increase in COE with CCS (post- & oxy-combustion)
  - < $400/kW fuel cell systems (2002$)
  - > 50% Plant efficiency, up to 60% with fuel cells
  - > 90% CO_2 capture
  - > 99% storage permanence of CO_2
  - +/- 30% storage capacity resolution

Coal Program Funding

Program (Thousand $)	FY 2007 (Adjusted)	FY 2008 (Adjusted)	FY 2009 Omnibus	FY2010 Request
FutureGen	52,504	67,444	0	0
Clean Coal Power Initiative	58,758	72,262	288,174	0
Innovations for Existing Plants	15,626	35,083	50,000	41,000
Gasification	55,468	52,029	65,236	55,000
Turbines	19,475	23,125	28,000	31,000
Sequestration	97,228	115,620	150,000	179,865
Fuels	21,513	24,088	25,000	15,000
Fuel Cells	61,653	53,956	58,000	54,000
Advanced Research	32,213	36,264	28,000	28,000
Total Coal	414,328	479,871	692,410	403,865
Earmarks/CDP Asia Pacific	24,650 7,000	+ 37,117 0	+ 32,541	

Technology Pathways

Innovations for Existing Plants

- **CO_2 capture for existing fleet**
- **Advanced concepts (e.g. oxy-combustion)**
- **Mercury control**
- **Water minimization technologies**

Air2Air™ condensing technology
San Juan Generating Station

Gasification Systems

- **Gasifier concept advances**
  - Cost reduction
  - Reliability improvement
- **Flexible and dry feed systems**
- **Syngas purification**
- **CO_2 separation**

Technology Pathways

Advanced Turbines for CCS

- Hydrogen turbines
- Oxygen-fired combustor/turbines

Fuel Cells

- Integrated Gasification Fuel Cell Systems (IGFC)
- CO_2 Capture Capable
- Up to 60% efficient coal-based electric power

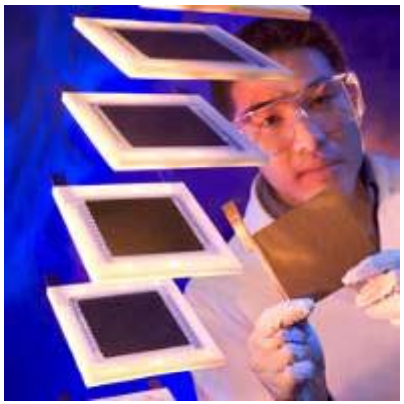


Photo courtesy of Ovonic

Technology Pathways

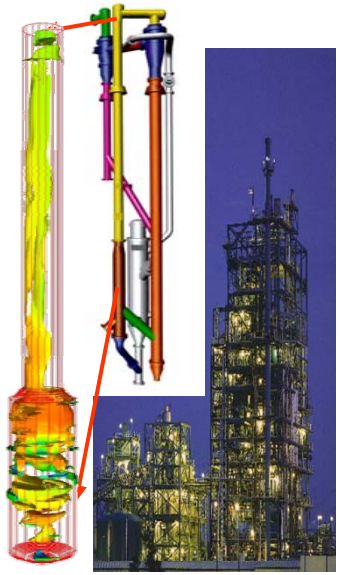
Fuels R&D

- Coal/biomass to transportation fuels
- Chemical feedstocks from coal
- Carbon Capture / Hydrogen membranes
- Micro Algae Produced Liquid Fuels

NETL Researcher recovering oil from microalgae

Advanced Research

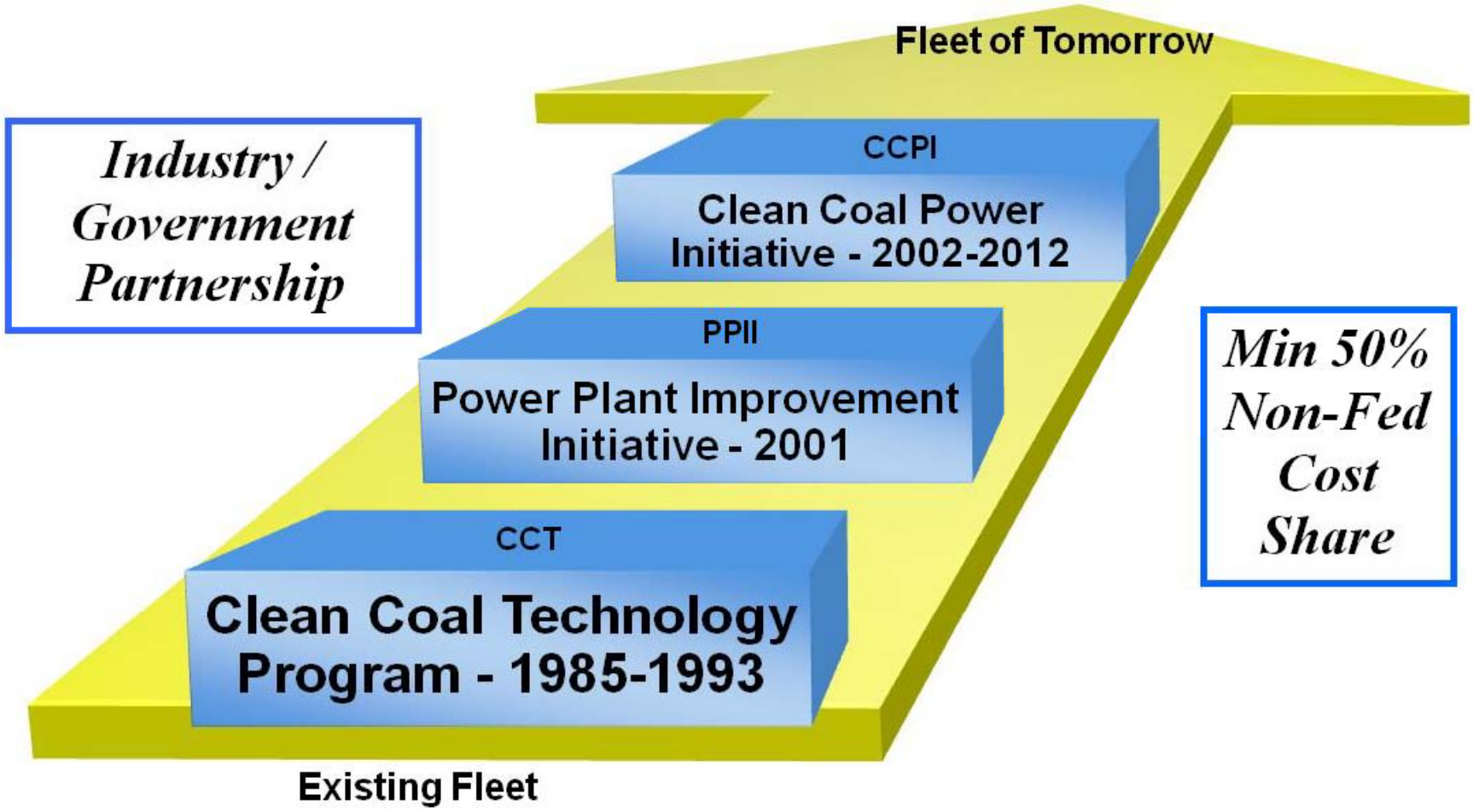
- Modeling & virtual simulation
- Sensors & process control
- Materials development



NETL-MFIX simulation KBR/Southern transport gasifier

DOE's Coal Demonstration Programs

A History of Innovative Projects



Fossil Energy ARRA

$3.4 billion

Expand and Extend Clean Coal Power Initiative (CCPI) Round 3 ***(Additional available CCPI funds total >$700 million)***	***$800 million ARRA*** ***$800 million Non-Federal*** ***$1.6 billion total***
Industrial Carbon Capture and Storage	***$1.52 billion ARRA*** ***$6.08 billion Non-Federal*** ***$7.60 billion total***
Geologic Sequestration Site Characterization	***$50.0 million ARRA*** ***$12.5 million Non-Federal*** ***$62.5 million total***
Geologic Sequestration Training & Research	***$20.0 million ARRA***
Carbon Capture and Storage ***(FutureGen Re-start)***	***$1.000 billion ARRA*** ***$ 73 million FE Coal Program*** ***$1.327 billion Non-Federal*** ***$2.400 billion total***
FE Program Direction	***$10.0 million ARRA***

For Additional Information

NETL

www.netl.doe.gov

Office of Fossil Energy

www.fe.doe.gov