



## **Roundtable: Advancing Carbon Capture in a Time of Challenge**

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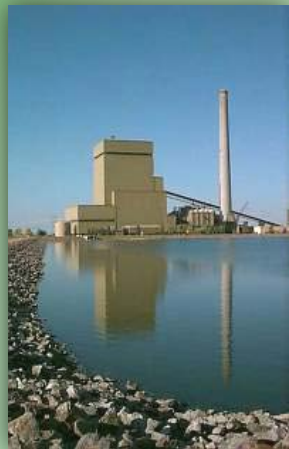
# Panel Introductions

- **Barry Jones, Global CCS Institute**
- **Ashok Bhargava, Asian Development Bank (Regrets)**
- **Juho Lipponen, International Energy Agency**



## Strategic Center for Coal

~500 Active Projects  
~\$16.3 B (\$5.8 B DOE)



Office of Coal and Power R&D

### Coal and Power R&D

- Carbon Capture
- Carbon Storage
- Advanced Energy Systems
  - Combustion
  - Gasification
  - Turbines
  - Fuel Cells
  - Fuels
- Advanced Crosscutting Research

Office of Major Demonstrations

### Major Demonstrations

- FutureGen 2.0
- Clean Coal Power Initiative (4)
- Industrial Carbon Capture and Storage (3)

Office of Program Planning and Analysis

### Program Planning & Analysis

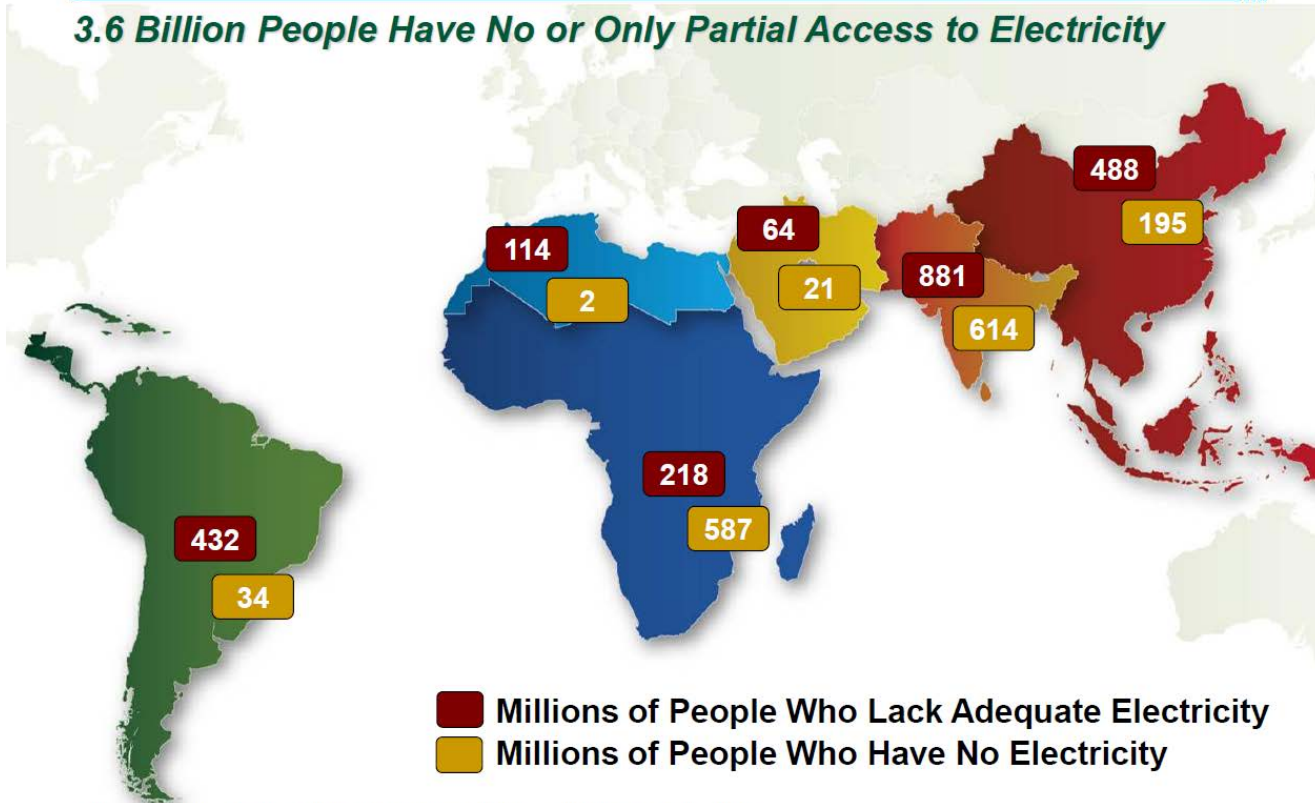
- Performance Division
- Program Benefits Division

### ➤ Significant Cost-Share

- Ensures Relevance of RD&D
- Leverages DOE Fund
- Promotes Commercialization

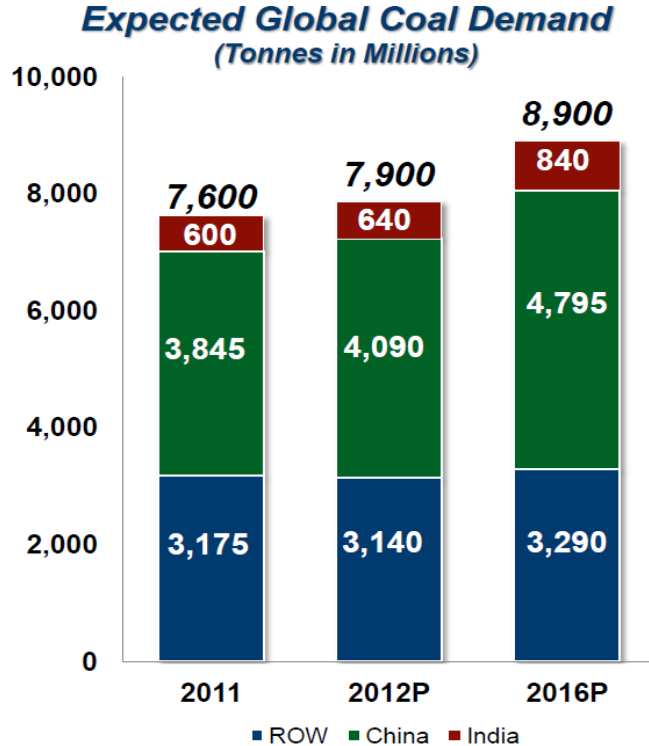
# Good Energy Access: A Rapidly Rising Need

*3.6 Billion People Have No or Only Partial Access to Electricity*



Source: International Energy Agency 2009 World Energy Outlook and The World Bank 2010.

# Annual World Coal Demand Expected to Grow ~1.3 Billion Tonnes in Five Years

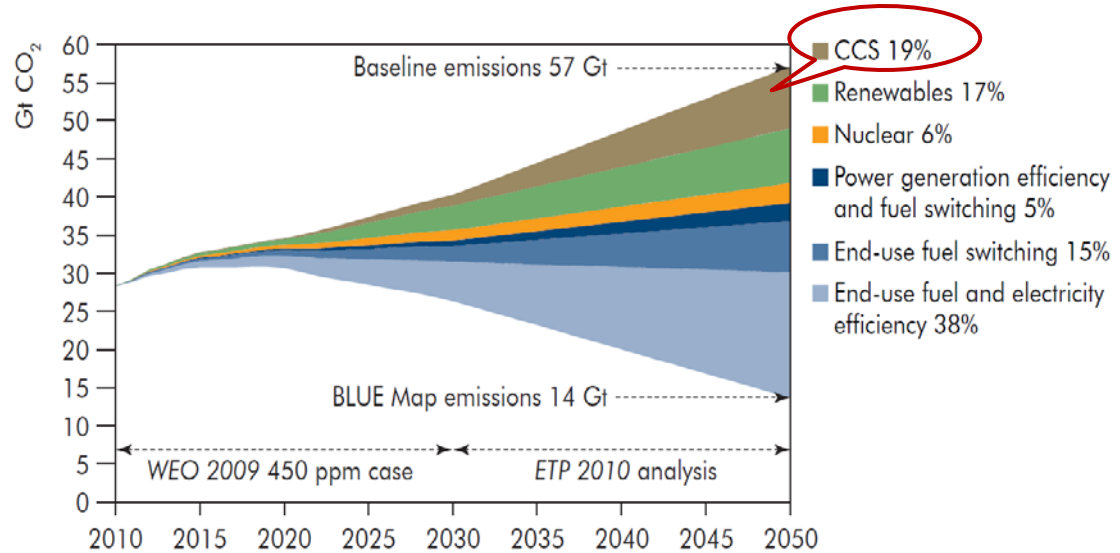


- New coal-fueled generation of 390+ GW expected by 2016
- Steel production expected to grow 20%, requiring additional 200 MTPY of metallurgical coal
- More than 85% of global demand growth in China/India
- Seaborne demand expected to grow at 8% CAGR

Source: Peabody Global Analytics.

# Carbon Capture Meets National and International Climate Goals

- **President Obama: By 2050, 83% reduction in GHG emissions from 2005 levels**
- **IEA: “application of CCS... represents potentially the most important new technology option for reducing direct emissions in industry.”**



Source: IEA. Energy Technology Perspectives 2010

# Responding to New Realities

## CCS Drivers – 2009 Realities

### Then



Pending carbon legislation



Oil @ \$50 - \$60 per barrel



High natural gas prices



High cost of CO<sub>2</sub> capture

### Now



No carbon legislation



Oil @ \$100/bbl



Low cost natural gas from shale



CO<sub>2</sub> capture costs must be driven to business case economics

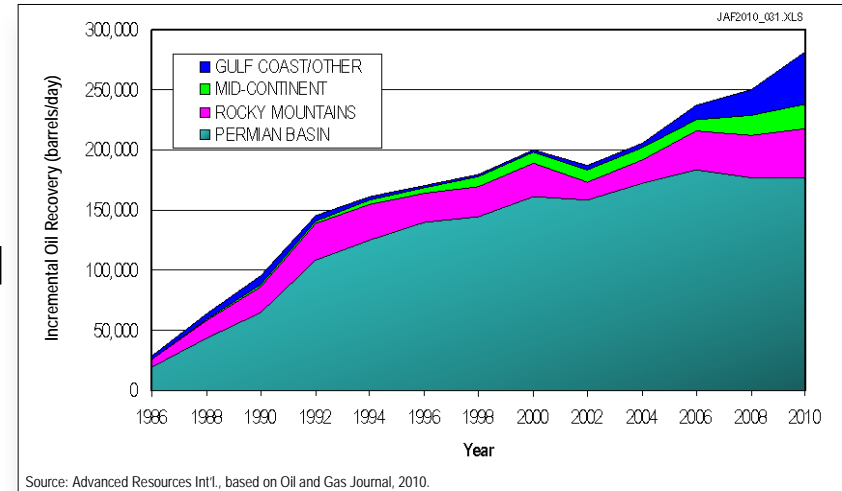
**CCUS is a business-driven path to promote CO<sub>2</sub> capture and storage**

**Strong incentive to continue to pursue carbon capture and storage**

# CCUS . . . Putting CO<sub>2</sub> to Work

## *Moving CCS Technology to Early Commercialization*

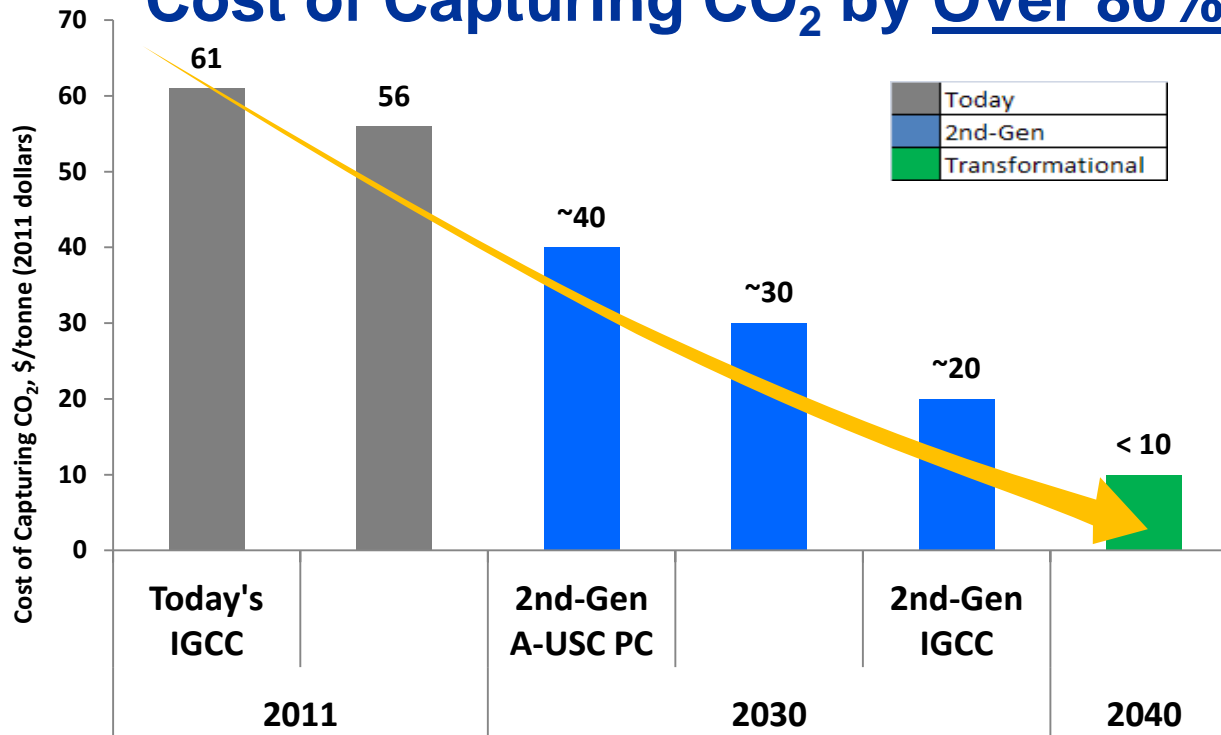
- EOR is the highest-value, highest-volume use of CO<sub>2</sub>
- In the United States, production from CO<sub>2</sub> EOR has *increased 40% over the past 6 years*
  - In 2010 it was 5% of total U.S. production
- EOR could potentially use CO<sub>2</sub> from 60 GW of U.S. power plants if Commercial Carbon Capture existed
- EOR can catalyze CCS technologies while providing economic drivers for commercial projects





# Fossil Energy Research Program Designed to Reduce the

## Cost of Capturing CO<sub>2</sub> by Over 80%

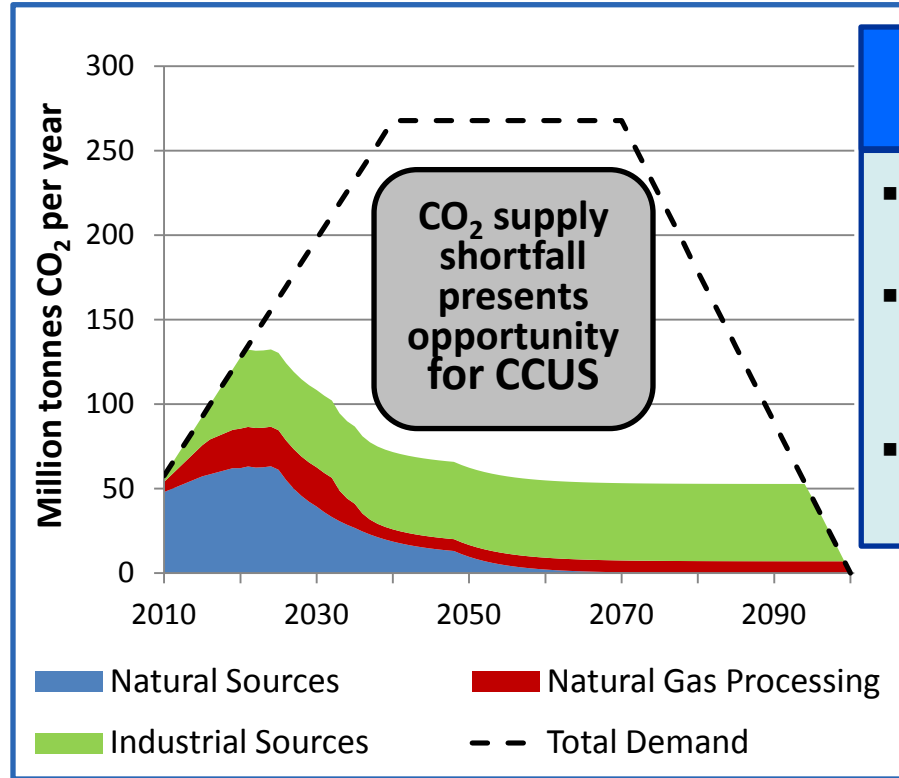


2011 costs are relative to a 2011 SCPC without CO<sub>2</sub> capture. 2030 and 2040 costs are relative to an A-USC PC without CO<sub>2</sub> capture. Costs are for the first year of plant operation and include compression to 2215 psia but exclude CO<sub>2</sub> transport and storage costs.

# Putting “U” in CCS → CCUS

## 60 Billion Barrels of Domestic EOR Potential

### Projected Supply and Demand for CO<sub>2</sub>

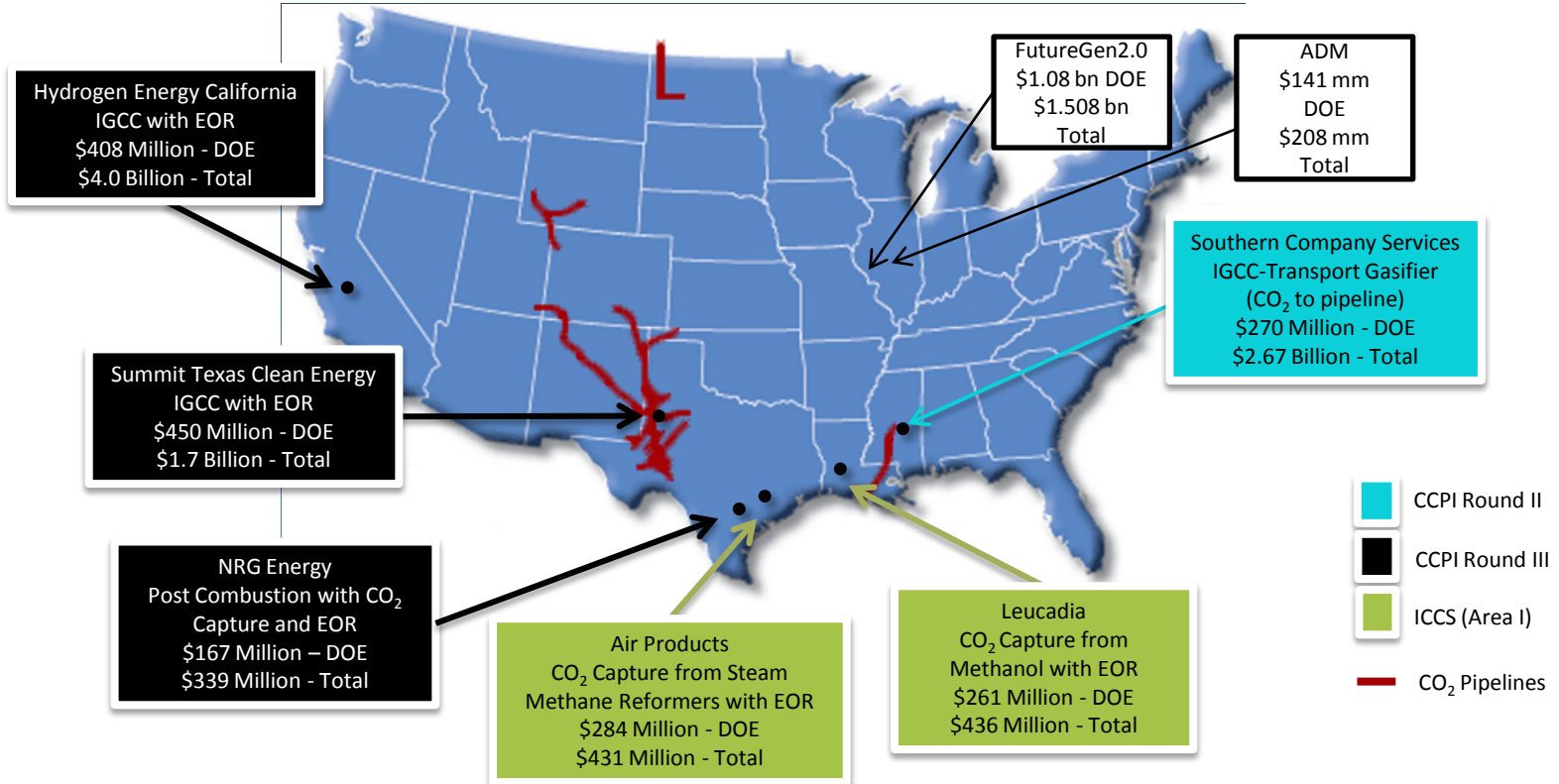


#### The Nation's CO<sub>2</sub> EOR Opportunity

- 60 billion bbls of oil produced by utilizing 17 billion tonnes of CO<sub>2</sub>
- 6 billion tonnes of CO<sub>2</sub> supplied by natural sources, industrial vents & gas processing
- 11 billion tonnes of CO<sub>2</sub> needed to fill projected shortfall in supply

# Major DOE CCUS Demonstrations

*Leveraging Existing Infrastructure and Creating New Markets*

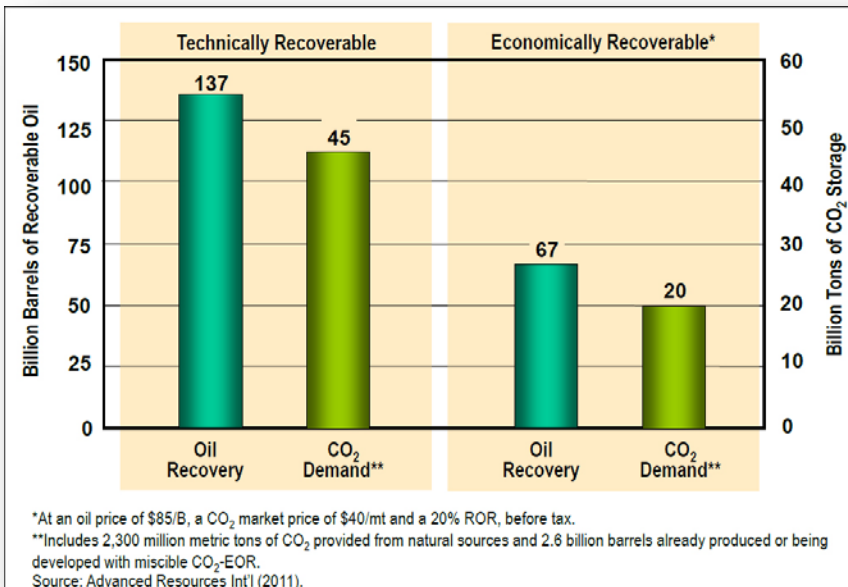


# The “Un-mined Gold” Story for Energy and Jobs

## Benefits of CO<sub>2</sub>-EOR

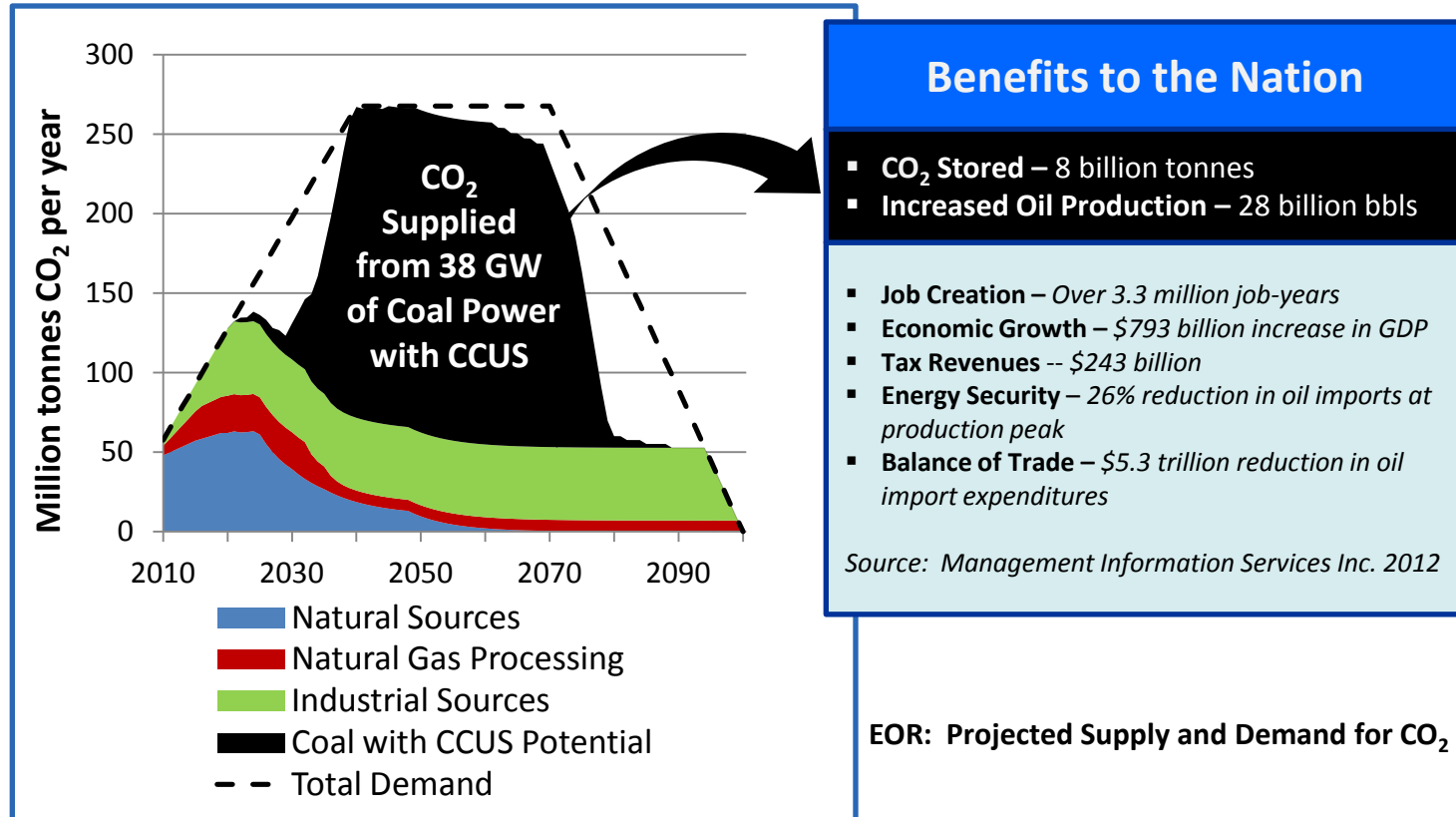
- **Improves Balance of Trade**  
\$3.5 trillion over 60 years
- **Promotes Energy Security**  
Reduces imports by 2 MMbpd<sup>1</sup>
- **Increases Domestic Activity**  
\$60 Billion/year (wages, royalties, taxes, profits)<sup>1</sup>
- **Creates Jobs**  
622,000 new jobs<sup>1</sup>

<sup>1</sup> Source : NETL Report, “Improving Domestic Energy Security and Lowering CO<sub>2</sub> Emissions with “Next Generation” CO<sub>2</sub> EOR,” June 2011



Domestic Oil Supplies and CO<sub>2</sub> Demand (Storage) Volumes from “Next Generation” CO<sub>2</sub>-EOR Technology

# Economic CCUS Deployment Opportunities Putting CO<sub>2</sub> to work for America



# Innovation and Technology

## *Key Technologies for CO<sub>2</sub> Utilization*

- **Advanced Energy Systems**
  - Gasification Systems
  - Hydrogen Turbines
  - Advanced Combustion Systems
- **Carbon Capture**
  - Post Combustion Capture
  - Pre-Combustion Capture
  - Oxy-combustion
- **Cross-cutting R&D**
  - Plant Optimization Technologies
  - Coal Utilization Science
  - Energy Analyses



*The National Carbon Capture Center  
in Wilsonville, Alabama*

# Technology Challenges For CCUS

## Cost

Current SOA capture technology >\$60 per tonne captured

## Energy Penalty

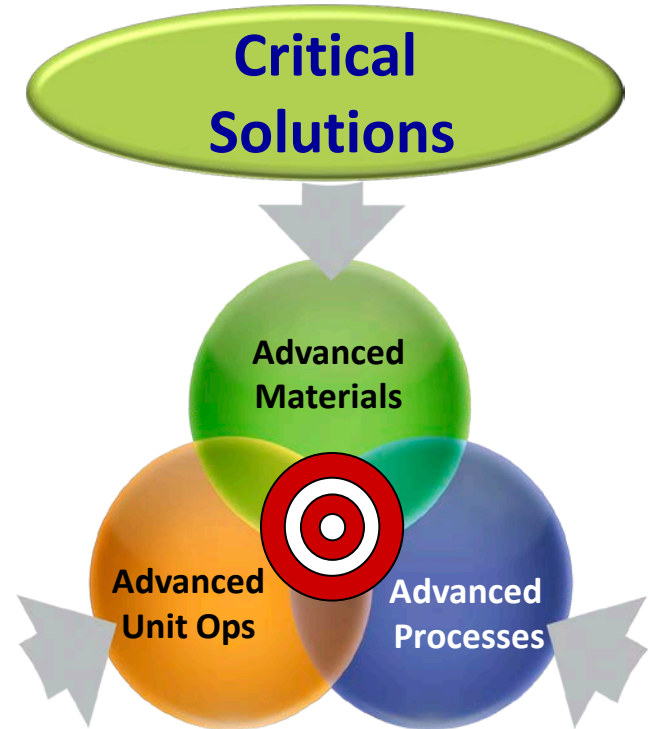
Current SOA capture technology has 20 - 30 percent energy penalty

## Scale

Advanced CO<sub>2</sub> capture technology is currently not to scale

## Also,...

Meeting criteria pollutant regulations (Hg, PM, SO<sub>x</sub>, NO<sub>x</sub>) and water consumption



# R&D Areas: CO<sub>2</sub> Capture

## Pre-Combustion

- Solvents
- Sorbents
- Membranes
- Hybrid processes
- Water-gas shift reactor



## Post-Combustion

- Solvents
- Sorbents
- Membranes
- Hybrid processes



## Oxy-Combustion

- Atmospheric oxy-combustion
- Pressurized oxy-combustion
- Oxygen transport membrane
- Chemical looping



## Advanced Compression

- Intra-stage cooling
- Cryogenic pumping
- Supersonic shock wave compression

