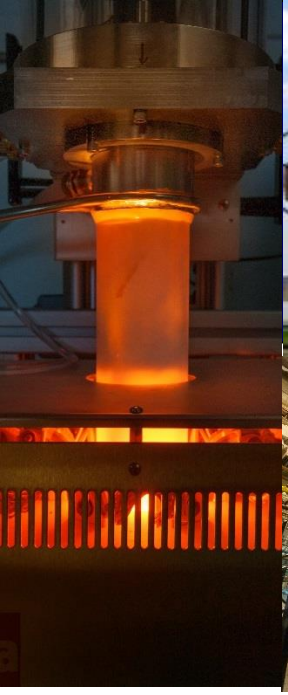
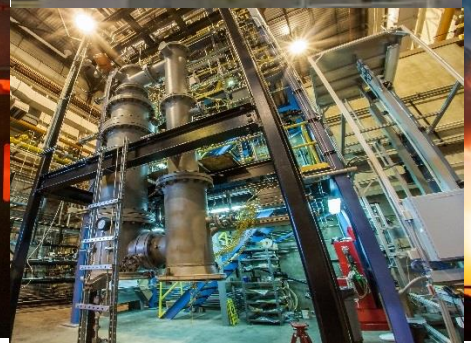
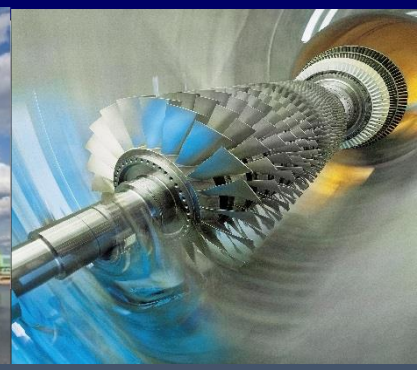




U.S. DEPARTMENT OF ENERGY | Office of Fossil Energy

US DOE CCUS Program Overview

John Litynski

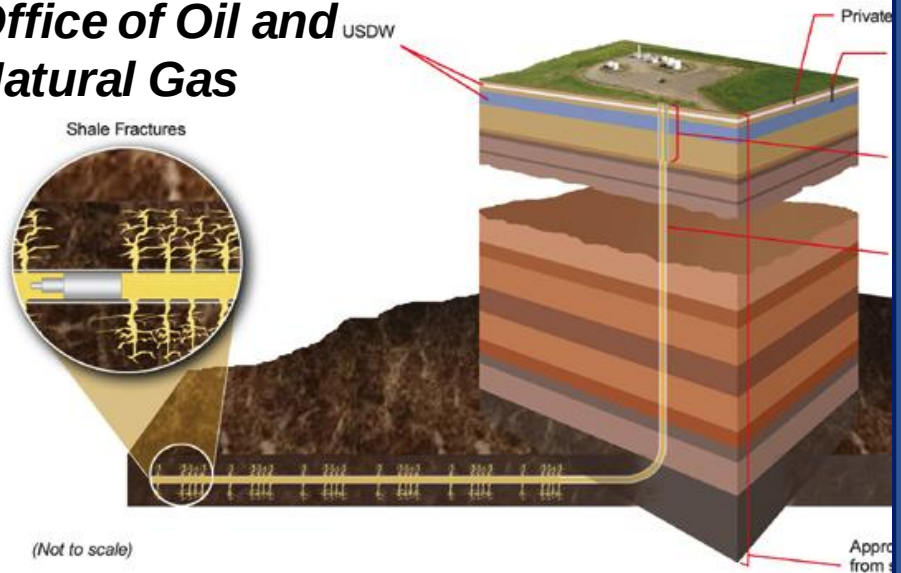
CCUS Division Director Acting

Carbon Capture Program Manager

Office of Fossil Energy

Office of Clean Coal and Carbon Management

Office of Oil and Natural Gas



Strategic Petroleum Reserves

National Energy Technology Laboratory

FE is Advancing Clean Coal Technologies

Making Coal Plants More Efficient

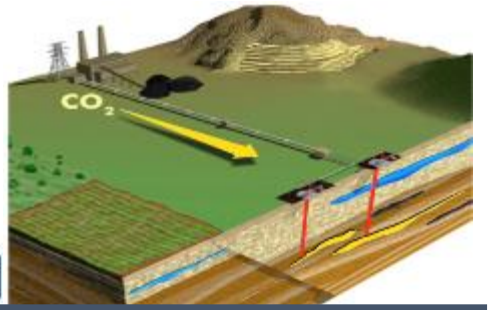
Gasification, Advanced Turbines, Advanced Combustion, and Fuel Cells

Capturing More CO_2

Cost-effective carbon capture for new and existing power plants

Turning CO_2 into Valuable Products

New pathways to utilize captured CO_2



CO_2 Utilization

Safe use and permanent storage of CO_2 from power generation and industry

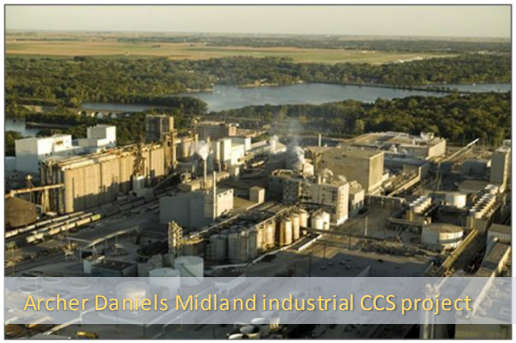
Bringing it All Together

Crosscutting technology development program

FY 17 Budget

FE R&D: $682M | Office of Petroleum Reserves: $248.5M

(in thousands)	FY17 Omnibus
TOTAL FOSSIL ENERGY	**930,450**
Coal	423,800
Carbon Capture	101,000
Carbon Storage	95,300
Advanced Energy Systems	105,000
Crosscutting	45,500
STEP	24,000
NETL Coal R&D	53,000
Fossil Proviso – large-scale pilots	50,000
Oil and Natural Gas	64,000
Natural Gas Technologies	43,000
Unconventional Fossil Energy Tech.	21,000
Other Corporate	60,700
Program Direction (HQ & NETL)	60,000
Special Recruitment Program	700
NETL	83,500
NETL Infrastructure	40,500
NETL Research and Operations	43,000
TOTAL FOSSIL ENERGY R&D	**682,000***
Office of Petroleum Reserves	248,450
Strategic Petroleum Reserve	223,000
Northeast Home Heating Oil Reserve	6,500
Naval Petroleum & Oil Shale Reserves	14,950



Archer Daniels Midland industrial CCS project

NETL, Chemical Looping Reactor

Bryan Mound SPR storage site

**Does not include $14,000 use of prior year balances or $246,515 rescission of prior year balances.*

FY 18 Budget Overview and Priorities

$280M for Fossil Energy R&D

- ✓ *Focus on cutting edge, early stage R&D*
- ✓ *Continue operations of the National Laboratories*

(in thousands)	FY18 Request
TOTAL FOSSIL ENERGY	**479,800***
Coal	114,800
Oil and Natural Gas	21,500
Other Corporate	58,678
NETL	141,200
TOTAL FOSSIL ENERGY R&D	**280,000***
Office of Petroleum Reserves	199,800

**Reflects total new Budget Authority funding; the total request is $335,178 with $55,178 in prior year balances to reach the requested amount of $280,000 for the FER&D budget.*

Coal Program Priorities

- Stabilize coal—improve the efficiency and reliability of coal-fired plants
- Carbon Capture, Utilization, and Storage (CCUS)

Oil and Gas Program Priorities

- Advance R&D to promote domestic production
- Infrastructure safety
- LNG Authorizations
- Advanced EOR

FY18 Budget (in thousands)	Request Level	House Mark	Senate Mark
TOTAL FOSSIL ENERGY R&D	280,000	668,000	572,700

Major Project Demonstrations

ADM Ethanol Facility
Decatur, IL

Kemper CCS Project
Kemper County MS

Petra Nova CCS Project
Thompsons TX

Air Products Facility
Port Arthur, TX

CCS Major Demos

Air Products Facility (Port Arthur, TX) - 2013

- State-of-the-art system to capture CO_2 from two large **steam methane reformers**
- CO_2 transported via pipeline to oil fields in eastern Texas for **EOR**
- Since 2013, **over 4 million metric tons of CO_2 captured**

Petra Nova CCS (Thompsons, TX) - 2017

- Demonstrate Mitsubishi Heavy Industries' technology to **capture 90% CO_2** from 240-MW flue gas stream (designed to **capture/store 1.4 million metric tons of CO_2/yr**)
- CO_2 used for **EOR** in West Ranch Oil Field in Jackson County, Texas

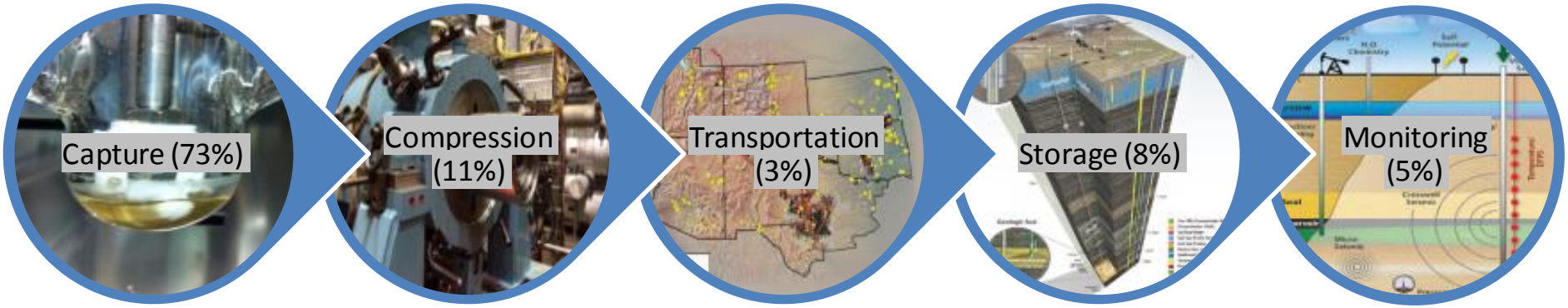
Kemper CCS Project (Kemper County, MS) - 2017

- **Transport Integrated Gasification™ (TRIG™) technology** developed jointly by DOE; Southern Company; Kellogg, Brown, and Root (KBR)
- **65% of CO_2 emissions** (~3 million metric tons/yr) **captured** and transported to depleted oil fields in Gulf coast region for **EOR**

ADM Ethanol Facility (Decatur, IL) - 2017

- **Capturing 1 million metric tons of CO_2 from ethanol biofuels production and store in deep saline reservoir**
- **First-ever CCS project** to use new U.S. Environmental Protection Agency (EPA) Underground Injection **Class VI well permit,** specifically for CO_2 storage

CCUS Economics



EOR/ECBM/Utilization

Source: NETL, Cost and Performance Baseline for Fossil Energy Plants, Revision 3, July 2015

Fossil Energy – Coal Research Program Goals

Driving Down the Cost of Electricity of Coal Power

FY18 Budget Request Goals

- Concludes 2nd Generation Goal
- Transformational Capture 2030 for new and existing units – COE & $/tonne captured
  - 90% removed from goal – OPTIMIZE Economics
- Transformational efficiency goals for new and existing units -TBD

Carbon Capture R&D Pathways

Pre-Combustion

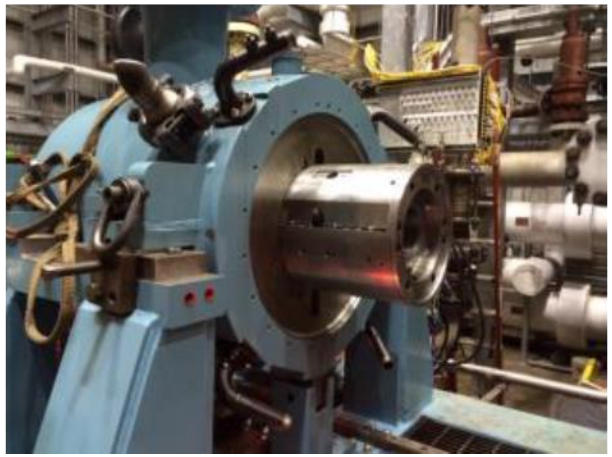
- ❑ *Solvents*
- ❑ *Sorbents*
- ❑ *Membranes*
- ❑ *Hybrid processes*
- ❑ *Water-gas shift reactor*

Post-Combustion

- ❑ *Solvents*
- ❑ *Sorbents*
- ❑ *Membranes*
- ❑ *Hybrid processes*

Advanced Compression

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

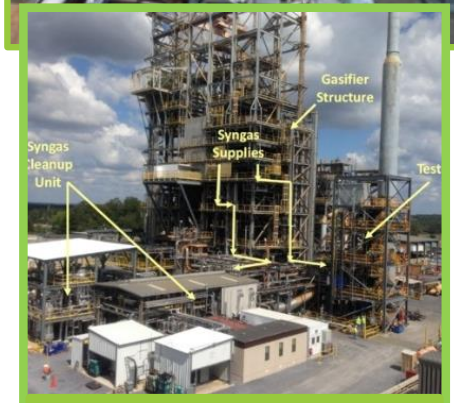


Post Combustion Capture
National Carbon Capture Center - Benefits to Program

- Operated by Southern Co Services
- Hosted at Plant Gaston, AL
- DOE funds 80% of operations
- Over 91,000 test hours *(10+years)*
- Technologies from U.S. and six other countries since 2008 founding of NCCC
- More than 40 carbon capture technologies tested
  - 20+ Post combustion
  - 20+ Pre-combustion
- Dedicated staff of plant engineers
- Standard design guidelines
- Small (0.05MWe) and Large (0.5MWe) Solvent Test Units
- 90+% of US developers opt for NCCC

Lab-Scale Unit

Bench-Scale Unit



TRIG - Gasifier

Small Pilot-Scale Unit

Carbon Capture Small Pilot Projects – up to 1.5 MWe

Decrease capital and energy costs

2nd Generation Technologies

- 10 post combustion systems
- Low degradation rates
- High permeance/reaction/flux
- ~$40/tonne

Transformational Systems

- Membrane systems for post combustion
- Solvent and sorbent systems for pre-combustion
- ~$30/tonne

Technologies ready for large scale testing

- 10 to 25MWe
- $60M for greenfield units
- 5000+ hours of testing for commercial viability

1 MW Solvent Pilot (Neumann)

1.5 MWe Solvent Pilot (Linde)

NCCC: 0.5 MW PSTU, 1 MW test bay

0.7 MWe Solvent System (Univ. of KY)

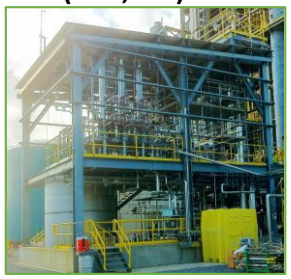
Cold Membrane System (Air Liquide)

2.7MWe Molten Carbonate (Fuel Cell Energy)

Alkalized Alumina Sorbent (TDA, Inc)

1 MW Membrane System (MTR)

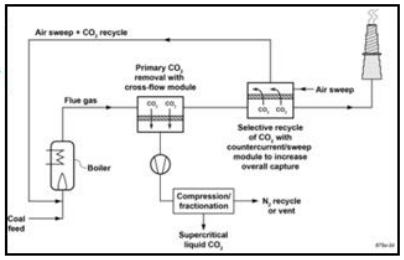
25 MW Solvent Heat Integration (Southern Company)



AC-ABC Pre Combustion (SRII)

Example of Technology Development Timeline – 2nd Gen

Feasibility study (DE-NT43085)
- Sweep concept proposed
- Polaris membrane conceived



APS Red Hawk NGCC Demo
- First Polaris flue gas test
- 250 lb/d CO_2 used for algae farm

APS Cholla Demo (DE-NT5312)
- First Polaris coal flue gas test
- 1 TPD CO_2 captured (50 kW_e)

NCCC 1 MW_e Demo (DE-FE5795)
- 10,000 hours of 1 TPD system operation
- 1 MW_e (20 TPD) system operation

Low Pressure Mega Module (DE-NT7553)
- Design and build a 500 m^2 optimized module

Hybrid Capture (DE-FE13118)
- Membrane-solvent hybrids with UT, Austin

B&W Integrated (DE-FE26414)

Future 10 MW_e Large Pilot

TRL3 TRL4 TRL5 TRL6 TRL7 TRL8

2006 2008 2010 2012 2014 2016 2018 2020

Accelerating the Rate of RD&D - Transformational

Partnership between national labs, academia, and industry

Accelerate deployment by 50% in TRL 2-5 range

Parallel paths for materials discovery – synthesis – process design

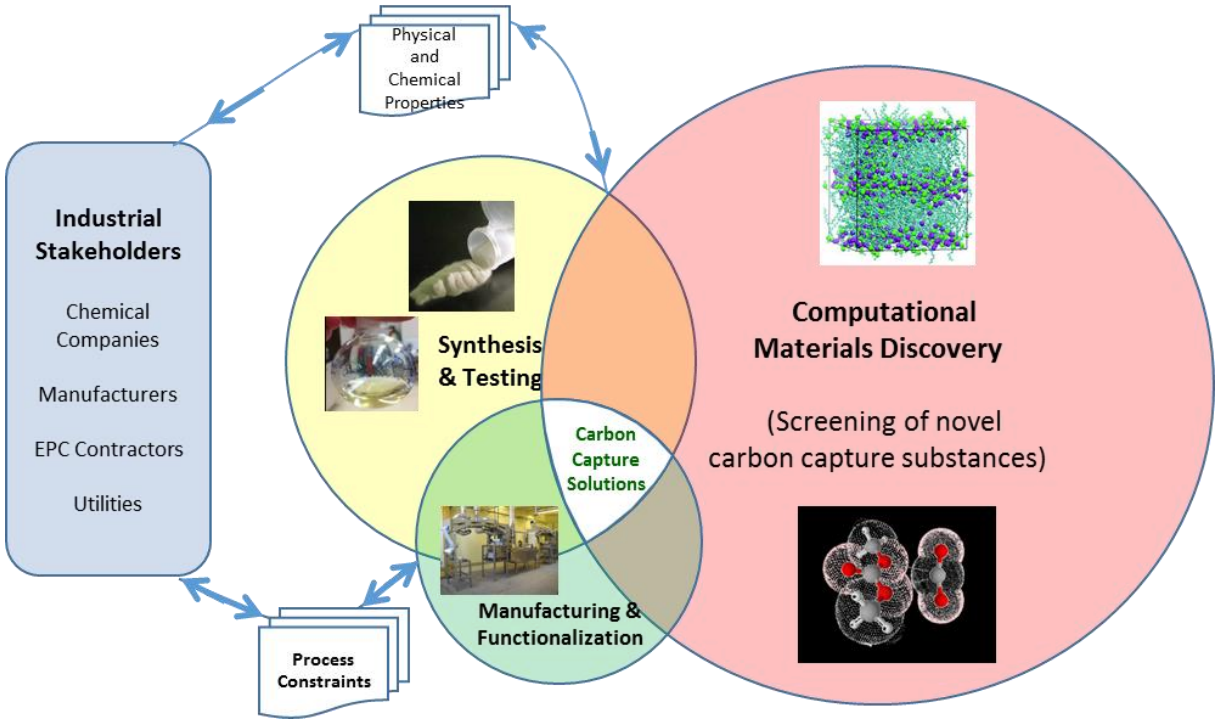
Leverage advanced computing

Robotics for rapid synthesis and analytical capabilities

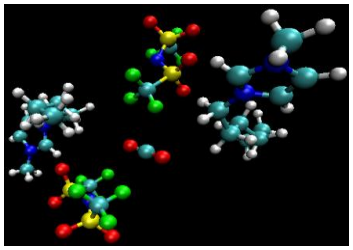
Lab Selection 2017

- **PNNL**
- **LBNL**
- **LLNL**

"Transformational Technology Development"



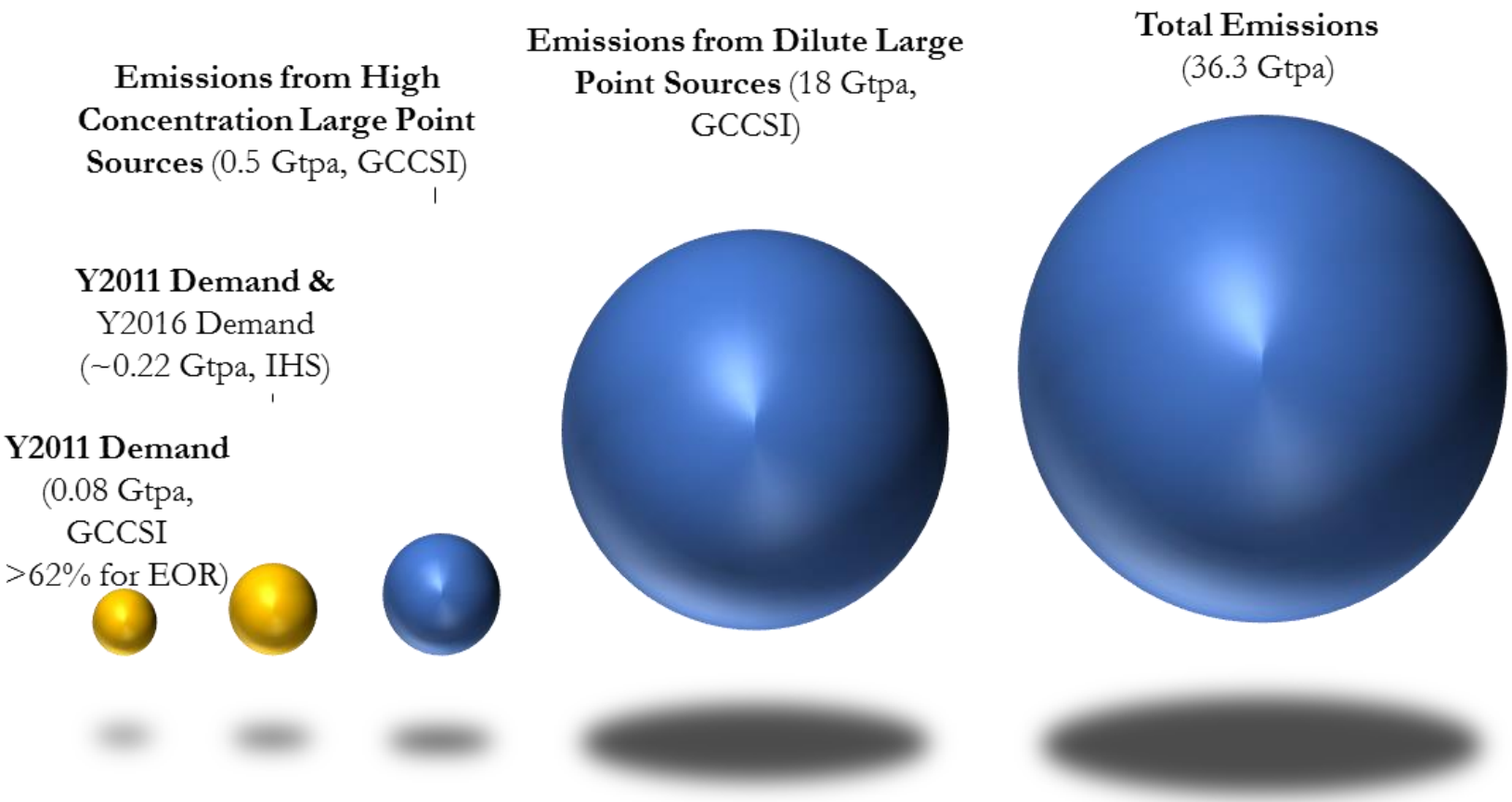
Non-aqueous and phase change solvents



Molecular Design

Advanced Manufactinrg

Global CO_2 demand and supply

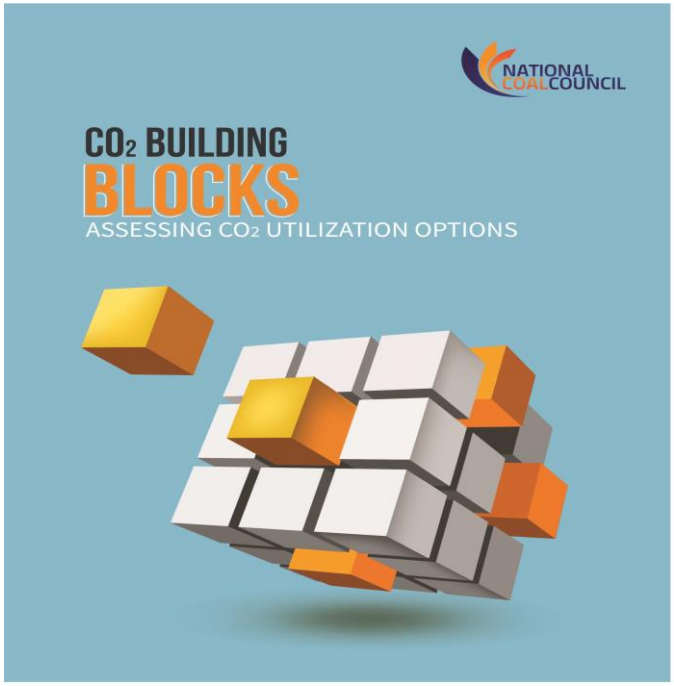


GCCSI, Parsons Brinckerhoff, "Accelerating the Uptake of CCS: industrial use of carbon dioxide" (Dec 2011);
Bala Suresh, IHS Markit, "Global Market for Carbon Dioxide", presented at 8th Carbon Dioxide Utilization Summit (Feb 2017)

Carbon Use and Reuse

Accelerate a Commercial Pathway to CCUS

- Carbon Utilization Reports
  - National Coal Council
  - National Academies of Science
  - Secretary's Advisory Board
- FOA closed 10/3/2016
- Two Rounds of Selections

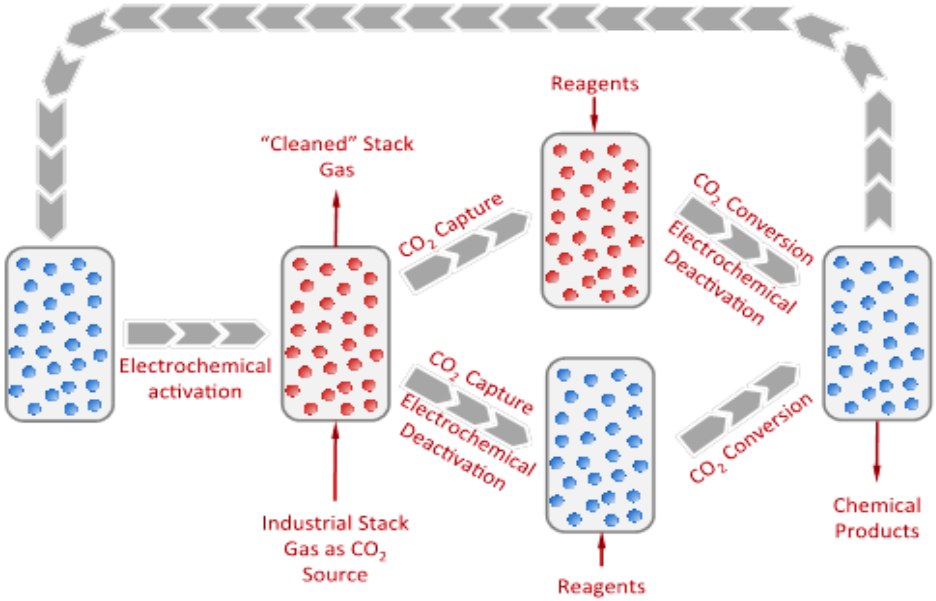


Carbon Use & Reuse

Offset CO_2 capture costs + Fix CO_2 in stable products

Biological Capture & Conversion

Fuels & Chemicals



Mineralization & Cements

Ten new projects selected/awarded between 2016-2017

Carbon Sequestration Leadership Forum


Australia


Brazil


Canada


China


Czech Republic


European Commission


France


Germany


Greece


India


Italy


Japan


Korea


Mexico


Netherlands


New Zealand


Norway

International Ministerial-level initiative focused on developing improved cost-effective technologies for carbon capture and storage (CCS). It also promotes awareness and champions legal, regulatory, financial, and institutional environments conducive to such technologies.

Mission to **facilitate development of CCS technologies** via collaborative efforts that address key technical, economic, and environmental obstacles.


Poland


Romania


Russia


Saudi Arabia


Serbia


South Africa


United Arab Emirates


United Kingdom


United States

U.S. DEPARTMENT OF ENERGY | Fossil Energy

Upcoming Meetings

December 2017: 7th Ministerial Meeting in Abu Dhabi, UAE

Clean Energy Ministerial/Mission Innovation

Clean Energy Ministerial

- **22 countries and European Union**
- **Represents 85-90% of global R&D investment**
- **Each country supports doubling of its R&D investment by 2021**
- **Separate private sector-led effort to invest in clean energy, focusing on early-stage innovation**
- **US and Saudi Arabia – CCUS Challenge Workshop – Sept 25-29, 2017**

"I don't believe you can have a real conversation about clean energy without including CCUS. The United States understands the importance of this clean technology and its vital role in the future of energy production." - U.S. DOE U.S. Department of Energy Secretary Rick Perry Rick Perry (6 June 2017, Beijing, PRC)

U.S. DEPARTMENT OF ENERGY | Fossil Energy

Discussion