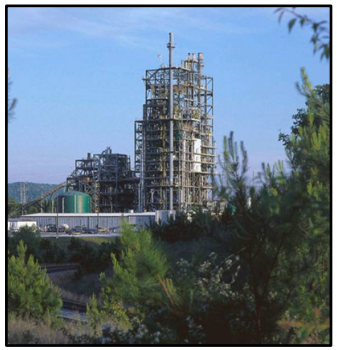

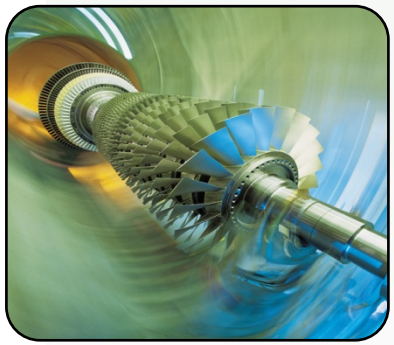

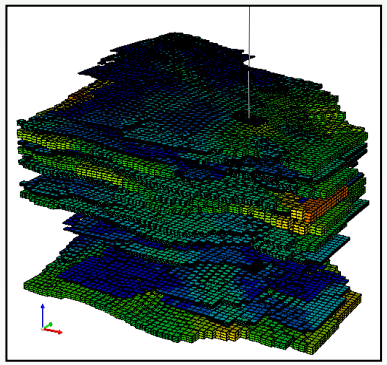

Current Activities of the DOE Office of Clean Coal & Carbon Management

2017 NASEO's National Energy Policy and Program Institute

Joseph Giove III

Director of Coal Business Operations

Office of Fossil Energy

July 26, 2017

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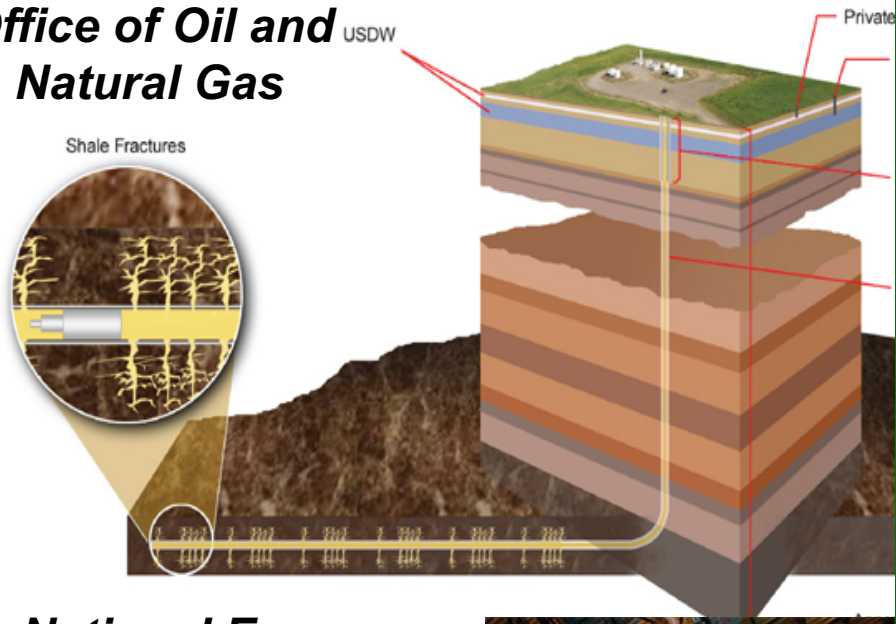
Office of Fossil Energy

Office of Oil and Natural Gas



National Energy Technology Laboratory

Advancing Clean Coal Technologies

Making Coal Plants More Efficient

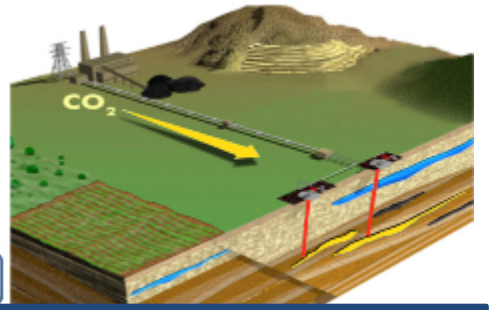
Gasification, Advanced Turbines, Advanced Combustion, and Fuel Cells

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

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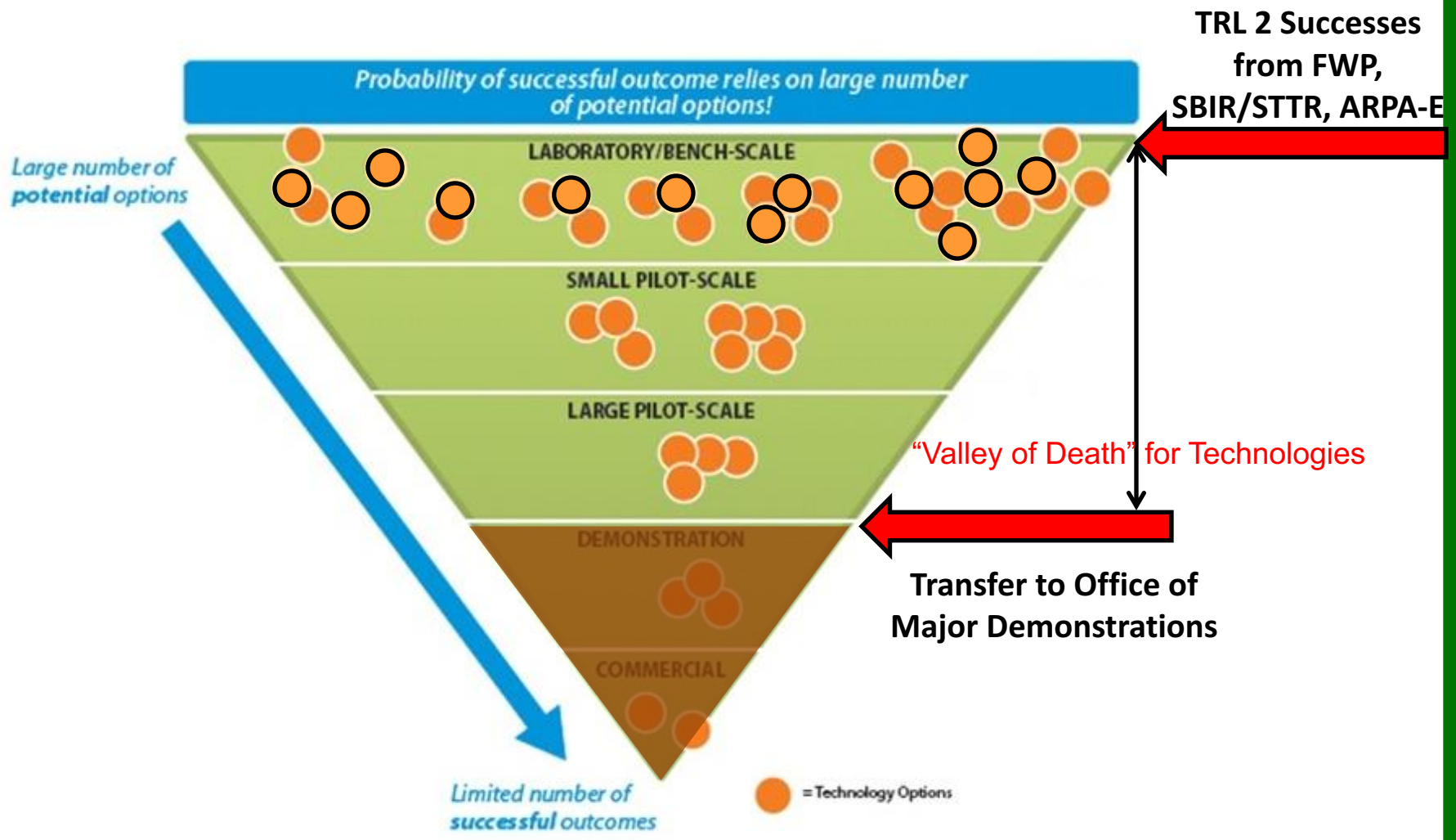
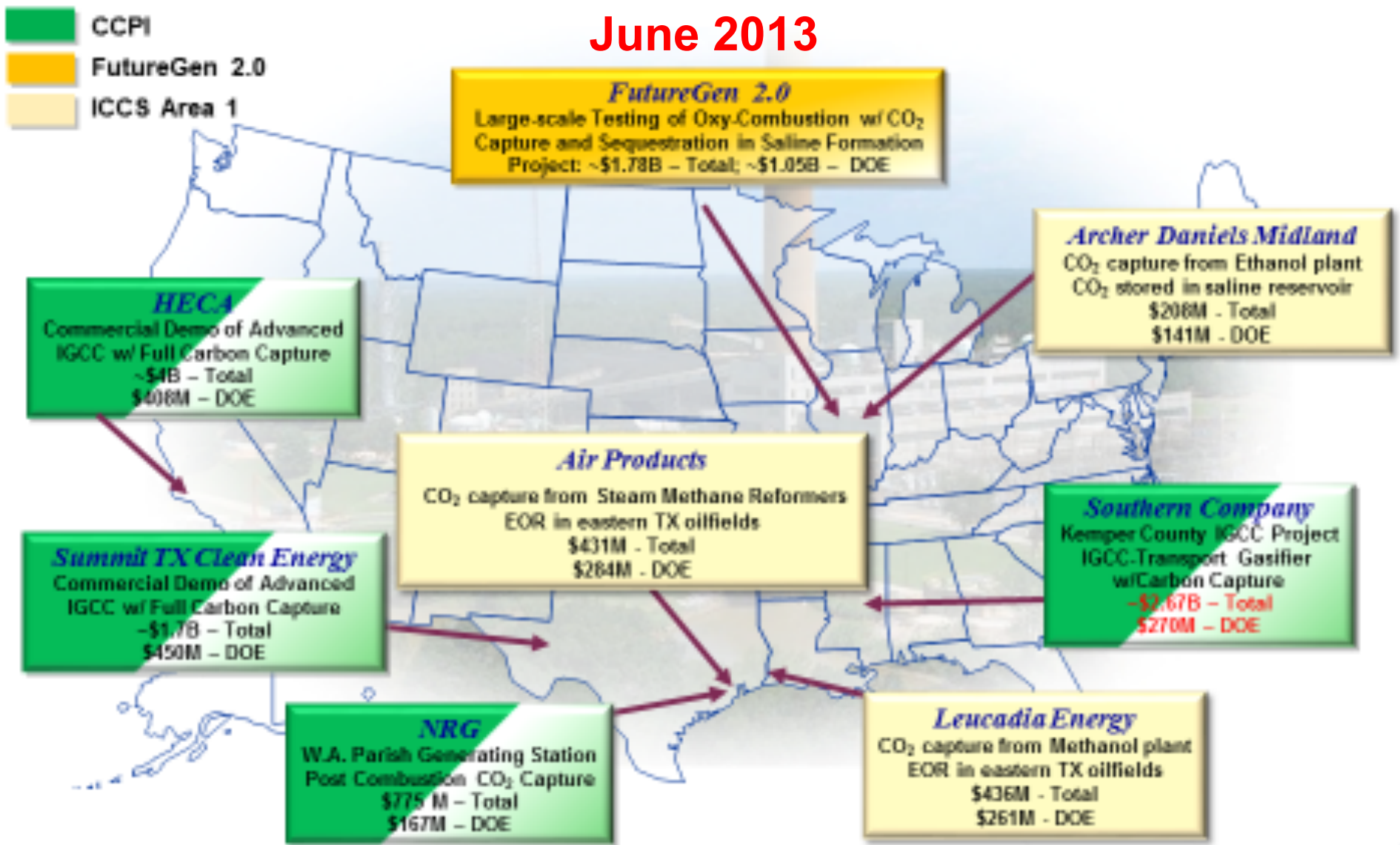
Fossil Energy R&D Program Office	FY 2017 Omnibus	FY 2018 Trump Request	FY 2018 (HEWD) HOUSE	FY 2018 (SEWD) SENATE
Coal	423,800	114,800	440,623	342,054
CCS and Power Systems	370,800	114,800	387,623	342,054
NETL Coal R&D	53,000	-	53,000	-
Natural Gas Technologies	43,000	5,500	28,200	45,018
Unconventional Fossil Energy Technologies	21,000	15,000	20,000	26,319
Special Recruitment Programs	700	200	700	200
Program Direction	60,000	58,478	60,000	57,000
NETL Infrastructure and Operations	40,500	63,100	40,500	58,683
NETL Research and Development	43,000	78,100	44,577	72,663
Fossil Energy R&D Subtotal	**$ 632,000**	**$ 335,178**	**$ 634,600**	**$ 601,937**
Coal Proviso	50,000	-	-	
Use of Prior Year Balances	(14,000)	(55,178)	-	(29,236)
Rescission of Prior Year Balances	(6,846)	-	-	-
Fossil Energy R&D Total	**$ 661,154**	**$ 280,000**	**$ 634,600**	**$ 572,701**
Office of Petroleum Reserves				
Strategic Petroleum Reserve	223,000	-	252,000	180,000
Strategic Petroleum Reserve - Petroleum Account	-	-	-	-
Northeast Home Heating Oil Reserve	6,500	-	6,500	6,500
Naval Petroleum and Oil Shale Reserves	14,950	-	4,900	4,900
Office of Petroleum Reserves Subtotal	**$ 244,450**	**$ -**	**$ 263,400**	**$ 191,400**
Use of Prior Year Balances	(4,000)	-	-	-
Rescission of Prior Year Balances	(5,343)	-	-	-
Office of Petroleum Reserves Total	**$ 235,107**	**$ -**	**$ 263,400**	**$ 191,400**
Office of Fossil Energy Total	**$ 896,261**	**$ 280,000**	**$ 898,000**	**$ 764,101**

Pathway for Technology Commercialization



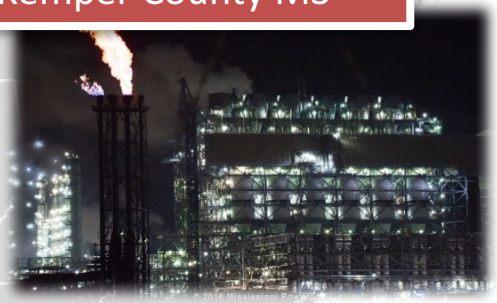
CCUS Projects
Locations, Technology & Cost Share



FE 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

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Petra Nova – NRG W.A. Parish

Advanced Post Combustion CO2 Capture

- Project at NRG's W.A. Parish power plant near Houston
- Retrofit of Existing Coal Plant (Post-Combustion CO2 capture) to process flue gas from W.A. Parish unit 8
- World's largest post-combustion CO_2 capture system
- Project was completed On-Budget and On-Schedule
- Delivering and permanently storing around 1.4 million metric tons of CO_2 per year for EOR.
- 240 MWe slipstream – scaled-up to improve project economics
- Fuel: PRB sub-bituminous coal
- 90% CO_2 capture from supplied flue gas (KM CDR Process®)
- EOR at the Hilcorp West Ranch oil field.
- Total Project Cost: ~$1 billion (DOE Cost Share: $190M)
  - NRG Equity - $300 million
  - JX Nippon Equity – $300 million
  - JBIC Project Financing - $250 million
  - MHI – Technology Provider

Key Dates:

- Project Awarded: May 2010
- Air Permit: December 2012
- NEPA Record of Decision: May 2013
- Financial Close: July 2014
- Complete Construction: December 2016
- Project Construction Completed On-Budget and On-Schedule.
- Started Operations: January 10, 2017
- Project Ribbon cutting: April 13, 2017

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Southern - Kemper County
Advanced IGCC with CO2 Capture

- Mississippi Power's New Built Coal Plant
- Located In Kemper County, MS
- First Base Load Unit Built in 30 years and Located Away from the Coast after Hurricane Katrina
- Mississippi Power is a PSC Regulated Utility
- Part of Kemper Costs are Subject to PSC Rate Recovery
- Generation: 582 MWe (net) with duct firing
- 2 TRIG™ gasifiers developed by Southern Co. and KBR
- Fuel: Mississippi lignite
- 67+% CO_2 capture (Selexol® process)
- ~3,000,000 metric tons CO_2/year
- EOR: Denbury Onshore LLC
- Total estimated project cost: ~$7B
- DOE Cost Share: $407MM

Key Dates:

- Project Awarded: Jan. 30, 2006
- Project moved to MS: Dec. 5, 2008
- NEPA Record of Decision: Aug. 19, 2010
- Initiate excavation work: Sept. 27, 2010
- CC operation on Nat Gas: August 2014
- First Syngas production initiated: July 14, 2016
- Commercial Operations Expected: 5/30/17

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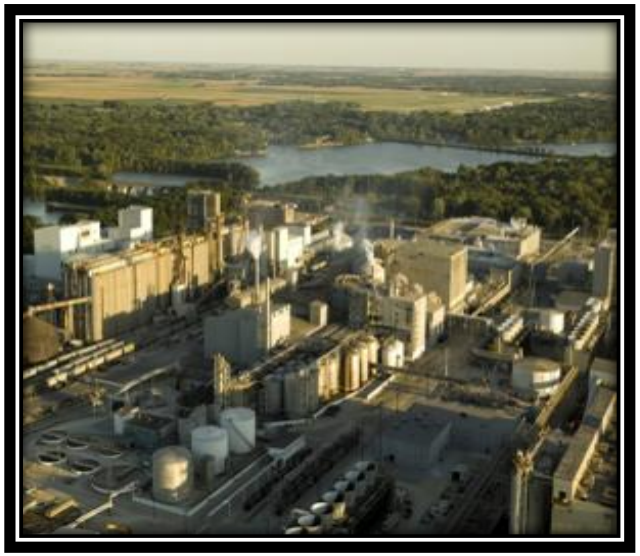
Archer Daniels Midland

CO2 Capture from Biofuel Plant

- CCS project built and operated by Archer Daniels Midland (ADM) at their existing biofuel plant
- located in Decatur, IL
- CO_2 is a direct by-product from production of fuel-grade ethanol via anaerobic fermentation
- Up to 90% CO_2 capture (with >99% CO2 purity), dehydration (via tri-ethylene glycol) & compression
- CO2 Sequestration in Mt. Simon Sandstone deep saline formation.
- Will be the first one to use the new EPA UIC Class VI well permit for CO2 capture.
- ~900,000 tonnes CO_2 /year captured and stored
- Total Project Cost: $208 MM.
- DOE Cost Share: $141 MM (68%)



Key Dates:

- FEED Completed: April 2011
- Construction started: May 2011
- Two monitoring wells drilled: Nov. 2012
- UIC Class VI Injection Well Permit: Sept. 2014;
- Injection well drilled and completed: Sept. 2015
- Construction ~99% complete Apr. 2016
- Awaiting final EPA authorization to start CO2 injections using Class VI UIC permit
- **Started Operations: April 7, 2017**

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Air Products & Chemicals

Steam Methane Reforming with CO2 Capture

- Built and operated by Air Products and Chemicals Inc. and located at Valero Oil Refinery in Port Arthur, TX.
- CO2 capture added to 2 existing Steam-Methane Reformers (SMRs) used for Hydrogen Production
- Project achieves 90+% CO_2 capture sing Vacuum Swing Adsorption (VSA) for CO2 separation
- Capturing ~925,000 tonnes CO_2/year
- ~30 MWe cogeneration unit makeup steam to SMRs and power to VSA and Compressors
- CO_2 to Denbury "Green" pipeline for EOR in Texas at West Hastings oil field
- Total Project cost: $431 MM;
- DOE Share: $284 MM (66%)
- Project was executed on time and under budget
- Has operated >100% of design when needed

Key Dates:

- FEED Completed: April 2011
- Construction started: May 2011
- Two monitoring wells drilled: Nov. 2012
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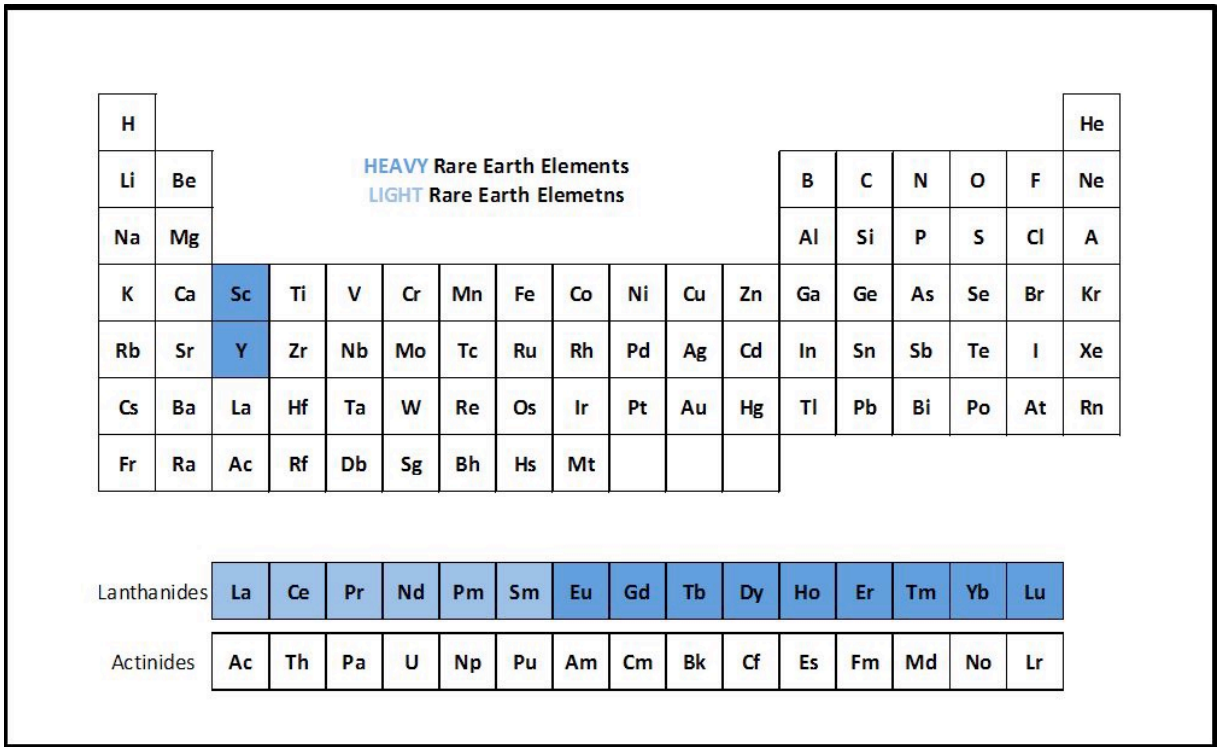
Rare Earth Elements (REEs)

- REE's are a family of 17 high-value elements including: lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), and lutetium (Lu). The rare earths are also often considered to include the metals scandium (Sc) and yttrium (Y).



Why are REEs Important?

Light Rare Earths	Major End-Use
Scandium	TVs, fluorescent and energy-saving lamps
Lanthanum	hybrid engines, metal alloys
Cerium	catalysts, metal alloys
Praseodymium	Magnets
Neodymium	catalysts, hard drives in laptops, headphones, hybrid engines
Promethium	watches, pacemakers
Samarium	Magnets
Europium	red color for television, computer screens

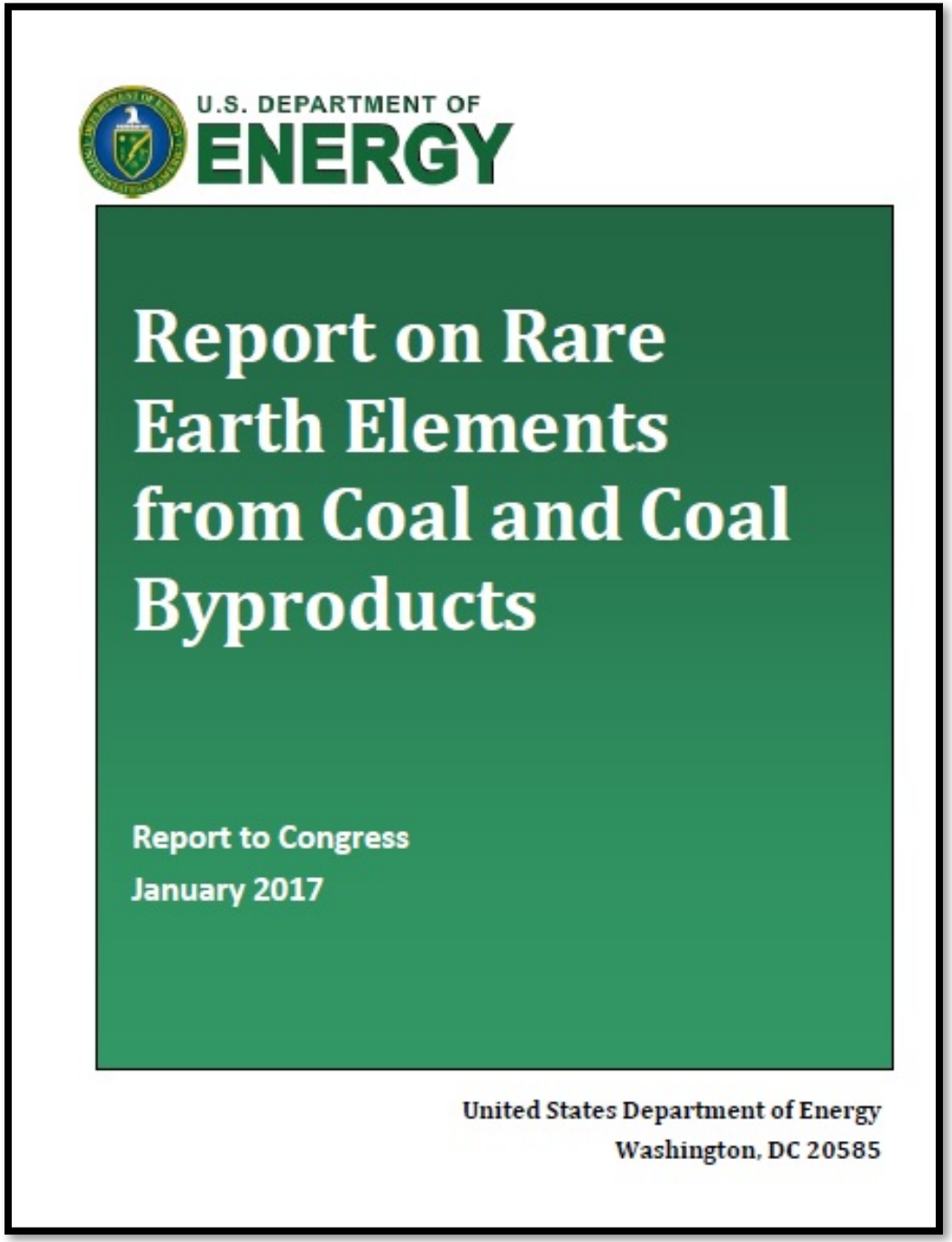
Heavy Rare Earths	Major End-Use
Terbium	phosphors, permanent magnets
Dysprosium	permanent magnets, hybrid engines
Erbium	phosphors
Yttrium	red color, fluorescent lamps, ceramics, metal alloy agent
Holmium	glass coloring, lasers
Thulium	medical x-ray units
Lutetium	petroleum catalysts
Ytterbium	lasers, steel alloys
Gadolinium	magnets

Why are REEs Important?

- The market for REE has been increasing since they were first mined in the mid-1900s. Historically, the U.S. has had a large market share, being the largest producer of REEs from the 1960s to the 1980s.
- China began production in the 1980s and by 1988 secured the position of the world's leading REE producer. China has controlled the global market throughout the majority of the last 30 years
- In 2011, global production of REEs was approximately 132,000 metric tons (MT)—95 percent of which was supplied by China.
- On September 1, 2009, China announced plans to reduce its export quota to 35,000 tons per year in 2010–2015 to conserve scarce resources and protect the environment.
- On October 19, 2010, *China Daily*, citing an unnamed Ministry of Commerce official, reported that China will "further reduce quotas for rare earth exports by 30 percent at most next year to protect the precious metals from over-exploitation"
- In March 2012, the US, EU, and Japan confronted China at WTO about these export and production restrictions. China responded with claims that the restrictions had environmental protection in mind.
- In August 2012, China announced a further 20% reduction in production.

Key Takeaways

- The strong global interest in developing an additional REE supply creates an investment opportunity for commercial firms seeking REEs recovered from coal and coal byproducts to find competitive entry points into the REE global value chain.
- REEs present in coal-based materials currently being mined for coal production represent potential savings when compared to production of virgin ore in a mine dedicated solely to REE recovery.
- The core challenges with REE recovery from coal and coal byproducts center on the large volume of material that must be processed to recover REEs.



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