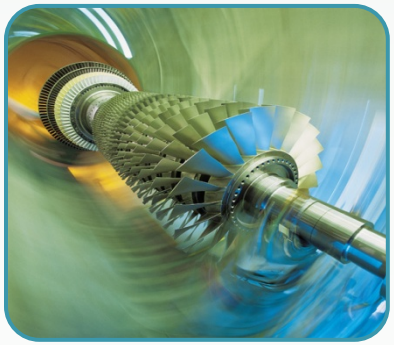


Overview of DOE's Office of Fossil Energy Priorities

2014 SSEB Committee on Clean Coal & Energy Technologies

Joseph Giove III

Director, Division of CCS Demonstrations

May 20, 2014

U.S. DEPARTMENT OF ENERGY | Fossil Energy

FE's Coal RD&D Investment Strategy

Approaches	Programs
Technology Development	**RESEARCH & DEVELOPMENT** Core Coal and Power Systems R&D *DOE – FE – NETL*
Commercial Readiness	**TECHNOLOGY DEMONSTRATION** FutureGen 2.0 Clean Coal Power Initiative Industrial CCS *DOE – FE – NETL*
Market Penetration	**FINANCIAL INCENTIVES** Tax Credits Loan Guarantees *DOE – LGO – IRS*

U.S. DEPARTMENT OF ENERGY | Fossil Energy

Key Priorities

Deliver the large CCS projects (both CCPI and ARRA) to maximum scientific and technical benefit

- **This accelerated deployment of clean coal technology provides key decision makers the technical and economic information needed for investment, regulation, and policy**

Support a diverse clean coal research program likely to bring to market large improvements in cost, efficiency, and performance

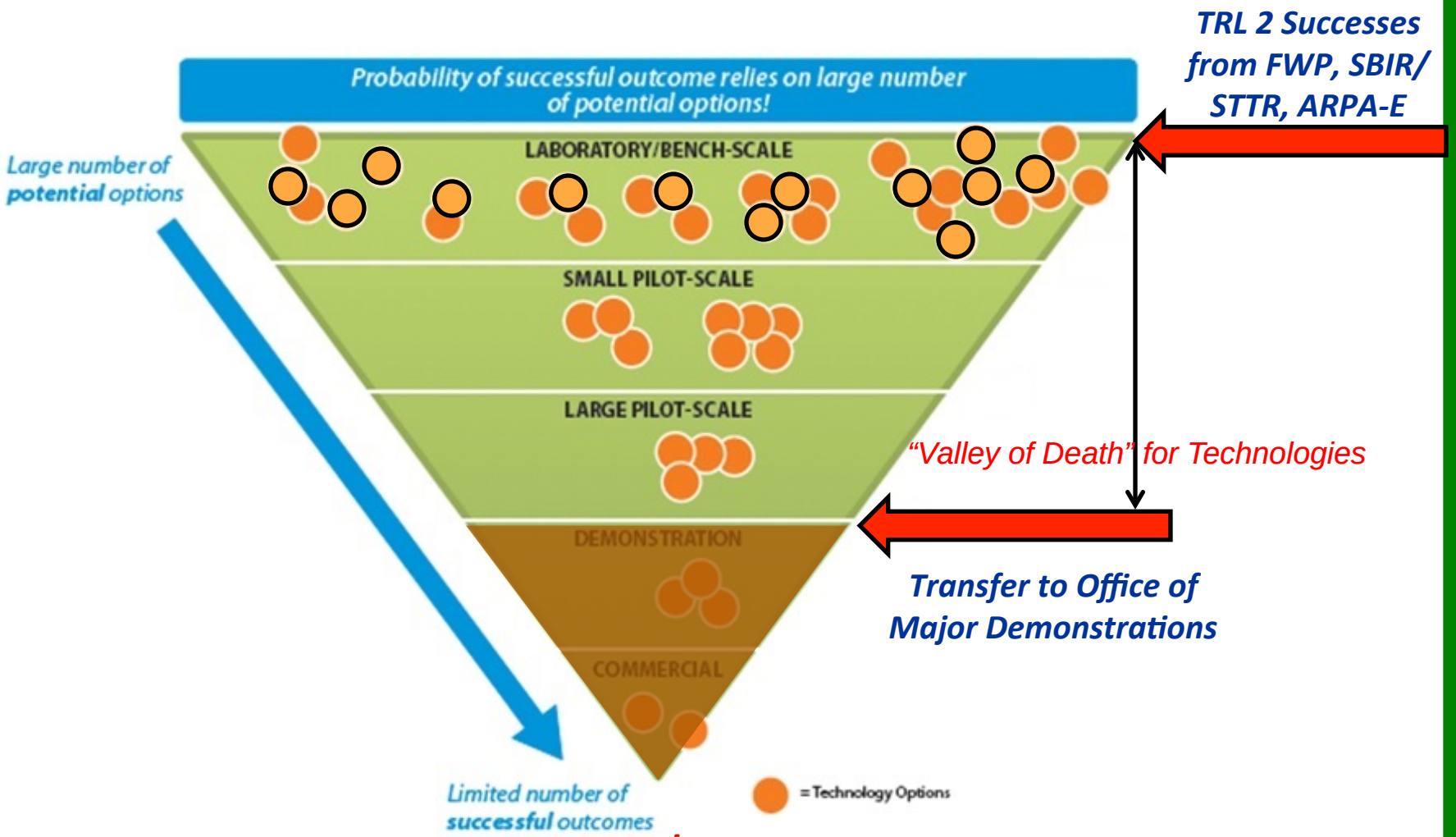
- **This increases the pool of potentially viable technologies that can serve commercial and industrial needs and reduces the risk of technical failure for public investments**

Ensure excellence in program design and execution

- **This serves the taxpayers, technical community, and industrial communities well**

Reduce cost of capture, reduce risk of storage

Pathway for Technology Commercialization



We need more 2nd generation pilots!

U.S. DEPARTMENT OF ENERGY | Fossil Energy

Capture Program: Active Portfolio Distribution

Supporting deployment of 2nd Generation Technologies

Program Area	Key Technology	Number of R&D Projects					Total
		TRL 1	TRL 2	TRL 3-4	TRL 5-6	TRL 7	
Post-Combustion Capture	*Solvents*		3	9	5	-	**17**
	Sorbents		3	9	2	-	**14**
	Membranes		4	5	1	-	**10**
	Hybrid/Novel		5	3	1	1	**10**
Pre-Combustion Capture	*Solvents*		2	1	→	-	**3**
	Sorbents		2	1	1	-	**4**
	Membranes		2	5	-	-	**7**
	Hybrid/Novel		3	-	-	-	**3**
Compression	*Compression*		-	-	2	-	**2**
TRL Totals			**24**	**33**	**12**	**1**	**70**

Need for transformational technology ideas
"Wave" of bench scale projects approaching graduation (1/2 of portfolio)
Up to 12 candidate ≤1MW pilots progressing toward large pilot-scale tests (10-50 MW)

U.S. DEPARTMENT OF ENERGY | Fossil Energy

CCS & Power Systems Funding
FY 2013 - 2015

($ in thousands)	FY 2013 Current	FY 2014 Enacted	FY 2015 Congressional Request
CCS demonstrations	**0**	**0**	**25,000**
Natural gas carbon capture and storage	0	0	25,000
CCS AND POWER SYSTEMS			
Carbon Capture			
Post-Combustion Capture Systems	51,336	80,000	65,000
Natural Gas CCS Prize	0	0	0
Pre-Combustion Capture Systems	12,389	12,000	12,000
Total Carbon Capture	**63,725**	**92,000**	**77,000**
Carbon Storage			
Storage Infrastructure (formerly Regional Carbon Sequestration Partnerships)	76,961	71,866	60,084
Geologic Storage	13,845	16,300	8,500
Monitoring, Verification, Accounting, and Assessment	6,229	10,000	4,500
Carbon Use and Reuse	719	800	0
Focus Area for Carbon Sequestration Science	8,991	9,800	7,000
Total Carbon Storage	**106,745**	**108,766**	**80,084**
Advanced Energy Systems			
Advanced Combustion Systems	14,790	18,500	15,000
Gasification Systems	36,051	36,000	22,000
Hydrogen Turbines	13,866	15,000	11,000
Coal and Coal Biomass to Liquids	4,621	5,000	0
Solid Oxide Fuel Cells	23,110	25,000	3,000
Total Advanced Energy Systems	**92,438**	**99,500**	**51,000**
Cross-cutting Research			
Plant Optimization Technologies	12,629	17,025	7,042
Coal Utilization Science	23,293	19,000	23,550
Energy Analyses	4,711	950	850
University Training and Research	3,699	3,600	2,750
International Activities	1,286	1,350	1,100
Total Cross-cutting Research	**45,618**	**41,925**	**35,292**
NETL Coal Research and Development			
Feasibility of Recovering Rare Earth Elements	**0**	**15,000**	**0**
NETL Coal R&D (Other)	**33,338**	**35,011**	**34,031**
NETL Coal Research and Development	**33,338**	**50,011**	**34,031**
TOTAL CCS AND POWER SYSTEMS	**341,864**	**392,202**	**302,407**

Major CCS Demonstration Projects

Project Locations & Cost Share

CCPI

ICCS Area 1

FutureGen 2.0

FutureGen 2.0
Large-scale Testing of Oxy-Combustion w/ CO_2 Capture and Sequestration in Saline Formation
Project: ~$1.65B – Total; ~$1.0B – DOE
SALINE – 1M MTPY 2017 start

Archer Daniels Midland
CO_2 Capture from Ethanol Plant
CO_2 Stored in Saline Reservoir
$208M – Total, $141M – DOE
SALINE – ~0.9M MTPY 2015 start

Summit TX Clean Energy
Commercial Demo of Advanced IGCC w/ Full Carbon Capture
~$1.7B – Total, $450M – DOE
EOR – ~2.2M MTPY 2019 start

HECA
Commercial Demo of Advanced IGCC w/ Full Carbon Capture
~$4B – Total, $408M – DOE
EOR – ~2.6M MTPY 2020 start

Southern Company
Kemper County IGCC Project
Transport Gasifier w/ Carbon Capture
~$4.7B – Total, $270M – -DOE
EOR – ~3.0M MTPY 2015 start

Petra Nova (formerly NRG)
W.A. Parish Generating Station
Post Combustion CO_2 Capture
$775 M – Total
$167M – DOE
EOR – ~1.4M MTPY 2017 start

Air Products and Chemicals, Inc.
CO_2 Capture from Steam Methane Reformers
EOR in Eastern TX Oilfields
$431M – Total, $284M – DOE
EOR – ~0.93M MTPY 2012 start

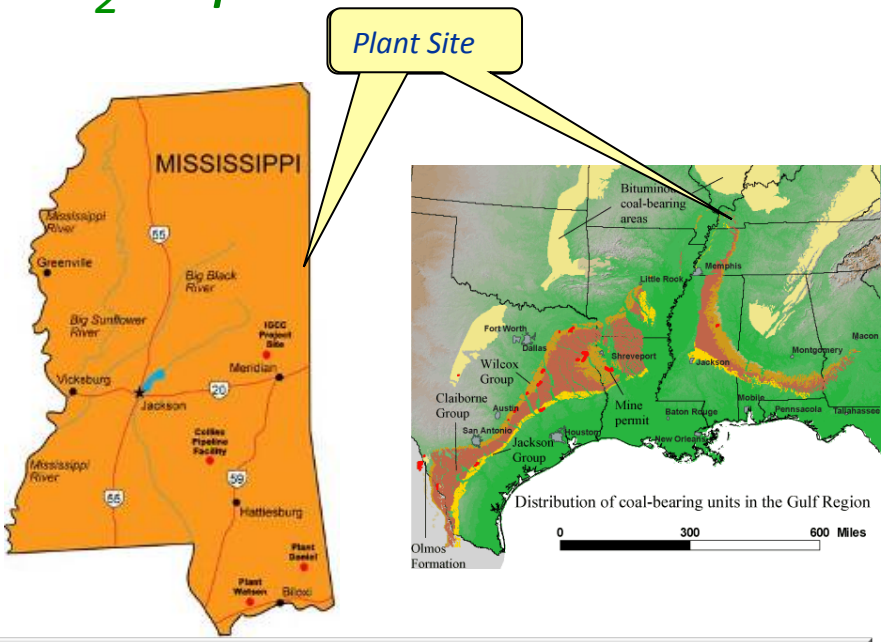
Leucadia Energy
CO_2 Capture from Methanol Plant
EOR in Eastern TX Oilfields
$436M - Total, $261M – DOE
EOR – ~4.5M MTPY 2017 start

U.S. DEPARTMENT OF ENERGY | Fossil Energy

Southern Company Services

Advanced IGCC with CO_2 Capture

- **Kemper County, MS**
- **582 MWe (net) IGCC: 2 Gasifiers, 2 Siemens Combustion Turbines, 1 Toshiba Steam Turbine**
- **Mississippi Lignite Fuel**
- **~67% CO_2 capture (Selexol® process) 3,000,000 tons CO_2/year**
- **EOR Denbury Onshore LLC, Treetop Midstream Services LLC**
- **Total Project: $4.7 Billion**
  DOE Share: $270 Million (6%)



Key Dates

- Project Awarded: January 2006
- Project moved to MS: December 2008
- Construction: July 2010
- NEPA ROD: August 2010
- Operations: Mid-2015

Status

- Plant construction >86% complete;>5,700 construction workers on site
- CO2 off-take agreements signed
- Lignite mine under development
- Subsystem in pre-commissioning
- Combustion turbine startup: Aug 2013
- Roll Steam Turbine: Oct 2013
- Gasifier heat-up: 3rd Quarter 2014


OxBlue™
Construction Camera Service


Kemper IGCC Project
March 2013

Hydrogen Energy California (HECA)

Advanced IGCC-Polygen w/CCUS

- Kern County, CA, EOR: Elk Hills oilfield
- Up to 300 MWe (net) with load following; greenfield IGCC; Urea/UAN production
  - MHI oxygen-blown gasifier (1 x 100%)
  - MHI G-class air cooled combustion turbine (1)
- Fuel: Sub-bituminous coal/petcoke
- 90% CO_2 capture – 3,020,000 tonnes CO_2/year
  - 2.57M tonnes/y EOR; 0.45M tonnes/y Urea production
  - 2-stage Water Gas Shift, Linde Rectisol ® AGR
- Use of brackish water for power production; ZLD
- Total DOE Project: $4 Billion DOE - $408 Million (10%)

Key Dates

- **Project Awarded: Sep 2009**
- **New Owner, SCS Energy: Sep 2011**
- **Financial Close: Mid-2015**
- **Start of Construction: Late 2015**
- **Start of Operation: Mid-2020**

Status

- **Power/Fertilizer/CO_2/EPC discussions in progress**
- **FEED completed: Jun 2013**
- **Draft EIS published: July 19, 2013**
- **Final Determination (Air Permit) – July 2013**

FutureGen 2.0

Oxy-Combustion w/ CO_2 Sequestration

- Morgan County, IL (western IL)
- 168 MWe repowering of an existing steam turbine generator at Ameren's Meredosia Energy Center
- Fuel: Illinois bituminous/PRB blend
- 90+% CO_2 capture (cryogenic separation) 1,000,000 tonnes CO_2/year
- Geologic Storage, Mt. Simon Sandstone saline formation - ~ 30 miles east of power plant
- Total DOE Project: $1.78 Billion
  DOE Share: $1.05 Billion (59%)

Key Dates

- **Project Awarded: October 2010**
- **NEPA Complete: Jan 13, 2014**
- **Financial Close: Summer 2014**
- **Construction: Summer 2014**
- **Operation: Winter 2017**

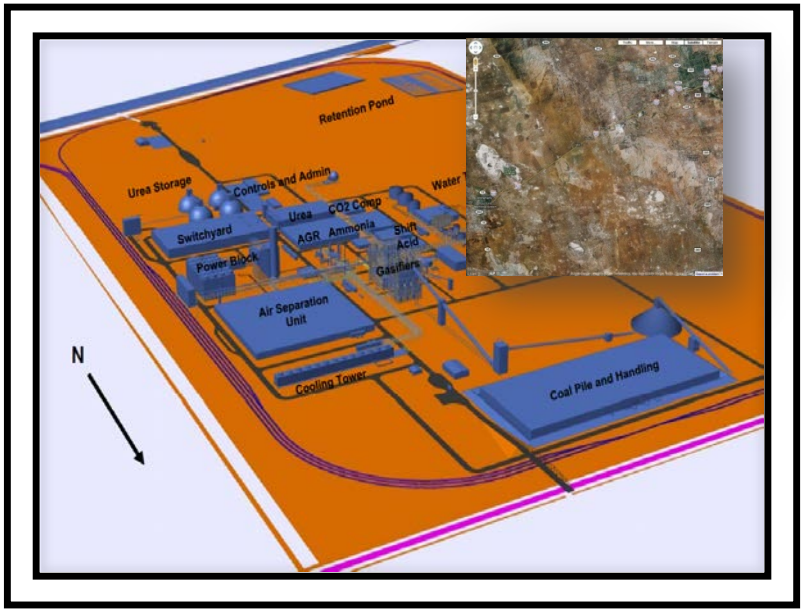
Status

- **Storage site selected: Oct 2011**
- **Power plant project novated to FGA: 1/30/13**
- **PPA signed: Aug 2013**
- **FEED completed: December 2013**
- **UIC Class VI Draft Permit Issued: March 2014**

Summit Texas Clean Energy

Advanced IGCC-Polygen w/CCUS

- Penwell, Ector County, TX
- 200 MW (net), 0.7M tonnes/yr Urea; greenfield IGCC with Siemens gasification & power Block
  - SFG-500 gasifiers (2 x 50%)
  - High H_2 SGCC6-5000F combined cycle (1 x 1)
- Fuel: PRB sub bituminous coal
- 90% CO_2 capture – ~2,700,000 tonnes CO_2/year
  - 2.2M tonnes/y EOR; 0.5M tonnes/y to Urea production
  - 2-stage Water Gas Shift, Linde Rectisol ® AGR
- EOR: Permian Basin Oilfields
- Total DOE Project: $1.727 Billion
  DOE Share: $450 Million (26%)
- Total Plant Cost ~$3.858 Billion (all in)



Key Dates

- **Air Permit; Dec 2010**
- **NEPA Record of Decision: Sep 2011**
- **Financial Close: Mid/Late 2015**
- **Construction: Late 2015**
- **Operation: 2019**

Status

- **Urea contract: Jan 2011**
- **CO_2 contract(s): Nov 2011**
- **Chexim signed for debt financing MOU: Sep 2012**
- **PPA/EPC under negotiations**

Petra Nova Parish Holdings (Formerly NRG)

Advanced Post Combustion CO_2 Capture

- Thompsons, TX (near Houston)
- 240 MWe slipstream at NRG Energy's W.A. Parish power plant (project scale up from original 60 MWe to improve economic)
- Fuel: PRB sub-bituminous coal
- 90% CO_2 capture (KM CDR Process®) 1,400,000 tonnes CO_2/year
- EOR: Hilcorp West Ranch Oilfield
- Total DOE Project: $775 Million (est.) DOE Share: $167 Million (21.5%)

Key Dates

- **Project Awarded: May 2010**
- **Air Permit: Dec 2012**
- **NEPA Record of Decision: Apr 2013**
- **Financial Close: June 2014**
- **Construction: June 2014**
- **Operation: 2017**

Status

- **EOR Host Site acquired: Oct 2011**
- **240 MWe FEED completed: Feb 21, 2012**
- **MHI initiated detailed design: Dec 2012**
- **ROD approved: 2013**
- **CFIUS Approval Complete – Feb 2014**
- **Limited Notice to Proceed – March 2014**

Archer Daniels Midland

CO_2 Capture from Biofuel Plant

- Decatur, IL
- CO_2 is a by-product (>99% purity) from production of fuel grade ethanol via anaerobic fermentation
- Up to 90% CO_2 capture; dehydration (via tri-ethylene glycol) and compression – ~900,000 tonnes CO_2 /year
- Sequestration in Mt. Simon Sandstone saline reservoir
- Total Project: $208 Million
  DOE Share: $141 Million (68%)

Key Dates

- **Phase 2 Awarded: Jun 15, 2010**
- **FEED Complete: Apr 2011**
- **NEPA FONSI: Apr 2011**
- **Construction start: May 2011**
- **UIC Class VI Injection Well Permit: Aug 2014**
- **Sequestration start: March 2015**

Status

- **Construction ~65% complete**
- **Two monitoring wells drilled: Nov 2012**
- **Commissioning compression and dehydration: began in July 2013**
- **Draft UIC Class VI permit issued: April 2014**

ADM - Project Photos (June 2013)

Four Compressor Train

Compressor & Auxiliaries

Dehydration System

8" High Pressure transmission Line

U.S. DEPARTMENT OF ENERGY | Fossil Energy

ADM - Project Monitoring Photos (June 2013)

Shallow Groundwater Sampling

Soil Gas and CO_2 Flux Networks

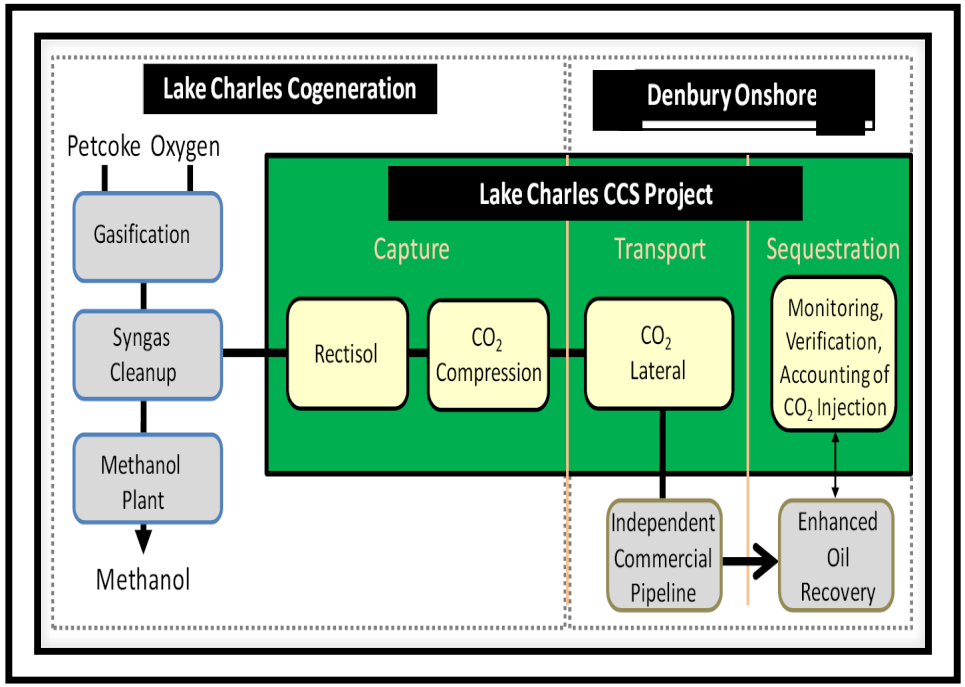
U.S. DEPARTMENT OF ENERGY | Fossil Energy

Leucadia Energy

Petcoke Gasification to Methanol

- Lake Charles, LA
- GE Energy Gasification

  (4 gasifiers: 3 hot/1 spare)
- 700 million gallons/year methanol; 110 mmscfd hydrogen
- Fuel; Petcoke
- 89% CO_2 capture (Rectisol® process); 4,500,000 tonnes CO_2/year
- CO_2 to Denbury pipeline for EOR in Texas at West Hastings oil field
- Total Project: $436 Million
  DOE Share: $261M (60%)



Key Dates

- **Phase 2 awarded: Jun 17, 2010**
- **NEPA ROD issued: Dec 2013**
- **Financial close: July 2014**
- **Construction: July 2014**
- **Operation: Late 2017**

Status

- **Product off-take contracts finalized (BP, APCI)**
- **FEED in progress for gasification plant**

Leucadia Site

Air Products & Chemicals

Steam Methane Reforming with CO_2 Capture

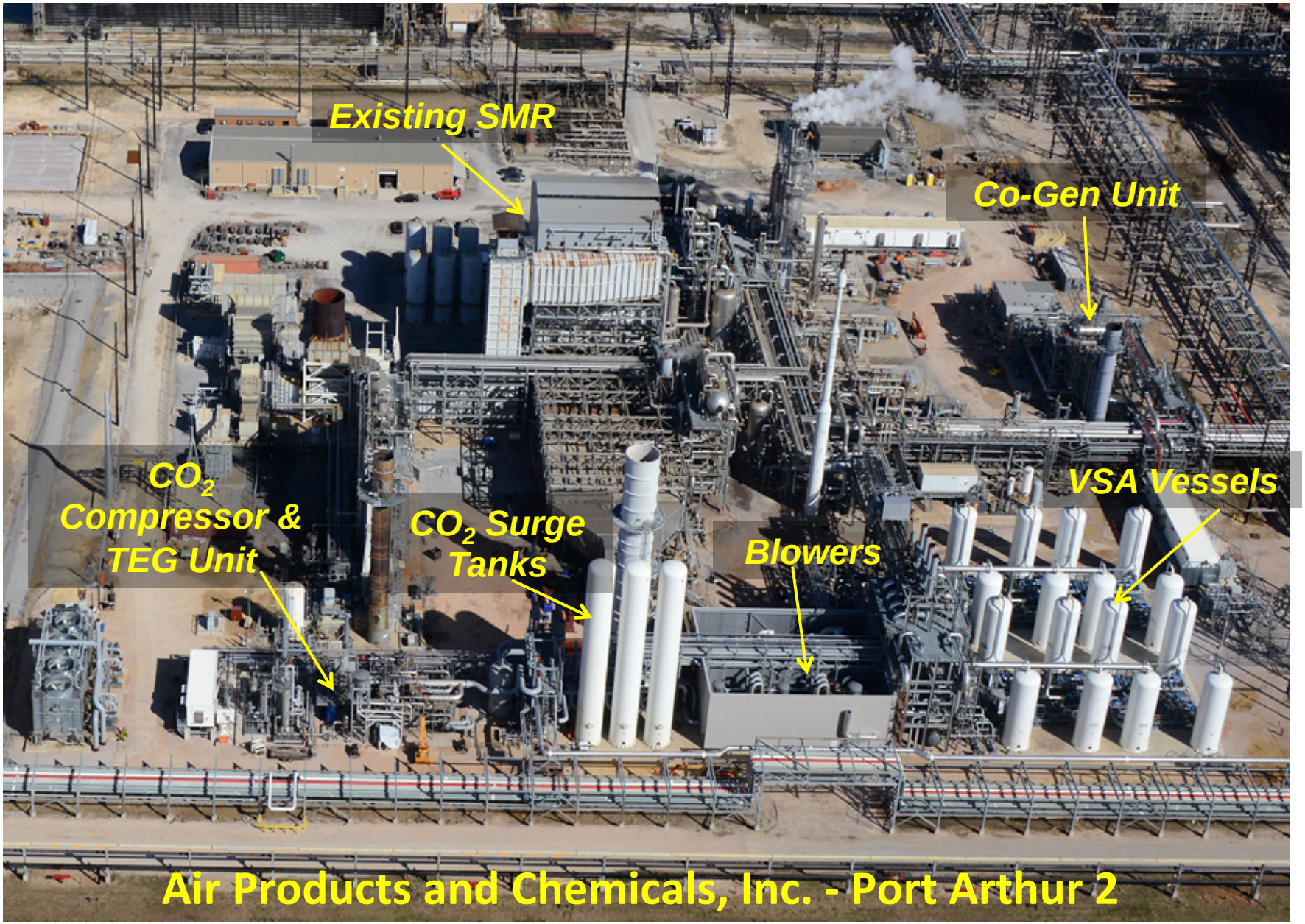
- Port Arthur, TX (Hydrogen plant at Valero Refinery)
- 90%+ CO_2 capture (Vacuum Swing Adsorption) from 2 steam-methane reformers (SMRs) yielding ~925,000 tonnes CO_2/year
- ~30 MWe cogeneration unit to supply makeup steam to SMRs and operate VSA and compression equipment
- CO_2 to Denbury for EOR - West Hastings oilfield
- Total Project: $431 Million
  DOE Share: $284 Million (66%)

Key Dates

- **Phase 2 Awarded: Jun 15, 2010**
- **FEED complete: Nov 2010**
- **Permit By Rule (PBR) and Standard Air Permits issued: May 2011**
- **NEPA FONSI: Jul 2011**
- **Construction start: Aug 2011**
- **Operation start: Dec 2012**
- **1MMT of CO_2 Sequestered: April 2014**

Status

- **PA-1 initiated operation: Mar 3, 2013**
- **PA-2 initiated operation: Dec 16, 2012**
  - **Operating continuously since Dec 31, 2012**
  - **Full capacity achieved: April 2013**
- **Final MVA report submitted: Feb 2013**

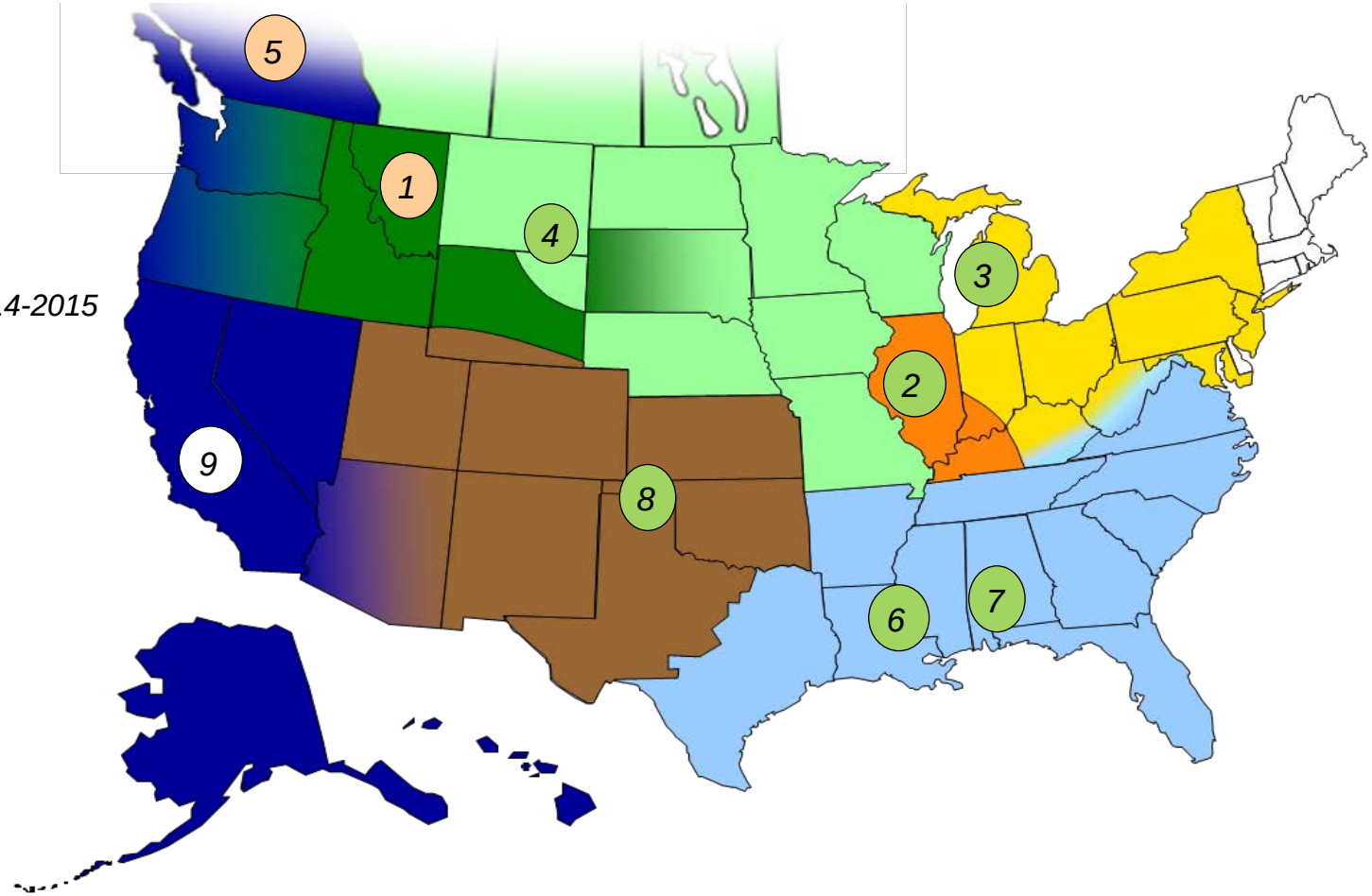


Air Products and Chemicals, Inc. - Port Arthur 2

RCSP Phase III: Large-Scale Geologic Tests

- ✓ *Six projects currently injecting CO_2*
- ✓ *Remaining injections scheduled 2014-2015*

- *Injection Ongoing*
- *Injection Scheduled 2014-2015*



Note: Some locations presented on map may differ from final injection location

U.S. DEPARTMENT OF ENERGY | Fossil Energy

RCSP Phase III: Large-Scale Geologic Tests

	RCSP	Geologic Province	Project Description	Injection Started & Volume to date (metric tons)
1	BIG SKY	Kevin Dome-Duperow Formation	Saline storage of naturally occurring CO_2	Injection to begin 2015; Volume TBD
2	MGSC	Illinois Basin-Mt. Simon Sandstone	Saline storage of CO_2 from ADM biofuel production	Injection began Nov. 2011; Volume >808,000 tonnes
3	MRCSP	Michigan Basin-Niagaran Reef	EOR using CO_2 from gas processing plant	Injection began Feb. 2013; Volume >328,000 tonnes
4	PCOR	Powder River Basin- Muddy Sandstone	EOR using CO_2 from ConocoPhillips Gas Plant	Injection began June 2013; Volume >429,000 tonnes
5		Horn River Basin-Carbonates	Saline storage of CO_2 from Spectra Energy gas processing plant	Injection to begin 2015; Volume TBD
6	SECARB	Gulf Coast – Tuscaloosa Formation	Saline leg of EOR; storage natural CO_2	Injection began 2009; Volume >3,000,000 tonnes
7		Gulf Coast – Paluxy Formation	Saline storage of amine capture CO_2 from coal-fired generation	Injection began Aug. 2012; Volume >100,000 tonnes
8	SWP	Anadarko Basin-Morrow Sandstone	EOR storage of CO_2 from fertilizer and ethanol plants	Injection began in Fall 2013; Volume >83,500 tonnes
9	WESTCARB	Regional Characterization		No large-scale injection

Injection Ongoing

Injection Scheduled 2014-2015

U.S. DEPARTMENT OF ENERGY | Fossil Energy

Advanced Fossil Energy Projects Solicitation

LPO Provides Project Finance Debt Capital

- $8 Billion in Loan Guarantee Authority for Fossil Energy
- Long-Term Financing Available

What is an Advanced Fossil Energy Project?

- Projects Must Be Innovative, Utilize Fossil Energy
- Reduce Greenhouse Gas Emissions
- Located in U.S. with Reasonable Prospect of Repayment

Application Process and Dates

- Long-term, Two-part Application Process: Open Until 2016
- **Part 1 Deadline: July 31, 2014 or December 05, 2014**
- Online Application Portal and Streamlined Review Process

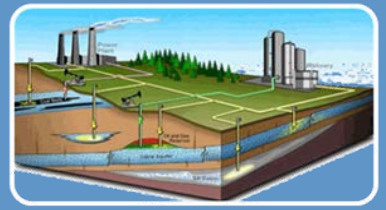
The Advanced Fossil Solicitation Covers Four Technology Areas*

Advanced Resource Development

- Coal-bed methane recovery
- Novel oil and gas drilling

Low Carbon Power Systems

- Chemical looping or process that isolate fuel from air during combustion
- Fuel cells which convert chemical energy into electricity without combustion



Carbon Capture

- CO_2 capture from traditional coal or natural gas electricity generation
- Permanent geologic storage or utilization in enhanced oil recovery (EOR)

Efficiency Improvements

- Combined heat and power (CHP) and waste recovery
- High-efficiency distributed fossil power systems, and microgrids

**Qualifying projects may include but are not limited to the technologies within.*

For Additional Information

Office of Fossil Energy
www.fe.doe.gov

NETL
www.netl.doe.gov

LGO solicitation homepage:
http://lpo.energy.gov/resource-library/solicitations/advanced-fossil-energy-projects-solicitation/

LGO Questions: LPO.FossilSolicitation.Questions@hq.doe.gov

U.S. DEPARTMENT OF ENERGY | Fossil Energy