Update on the Kemper IGCC with Pre-Combustion, and Petra Nova Post-Combustion Capture Projects

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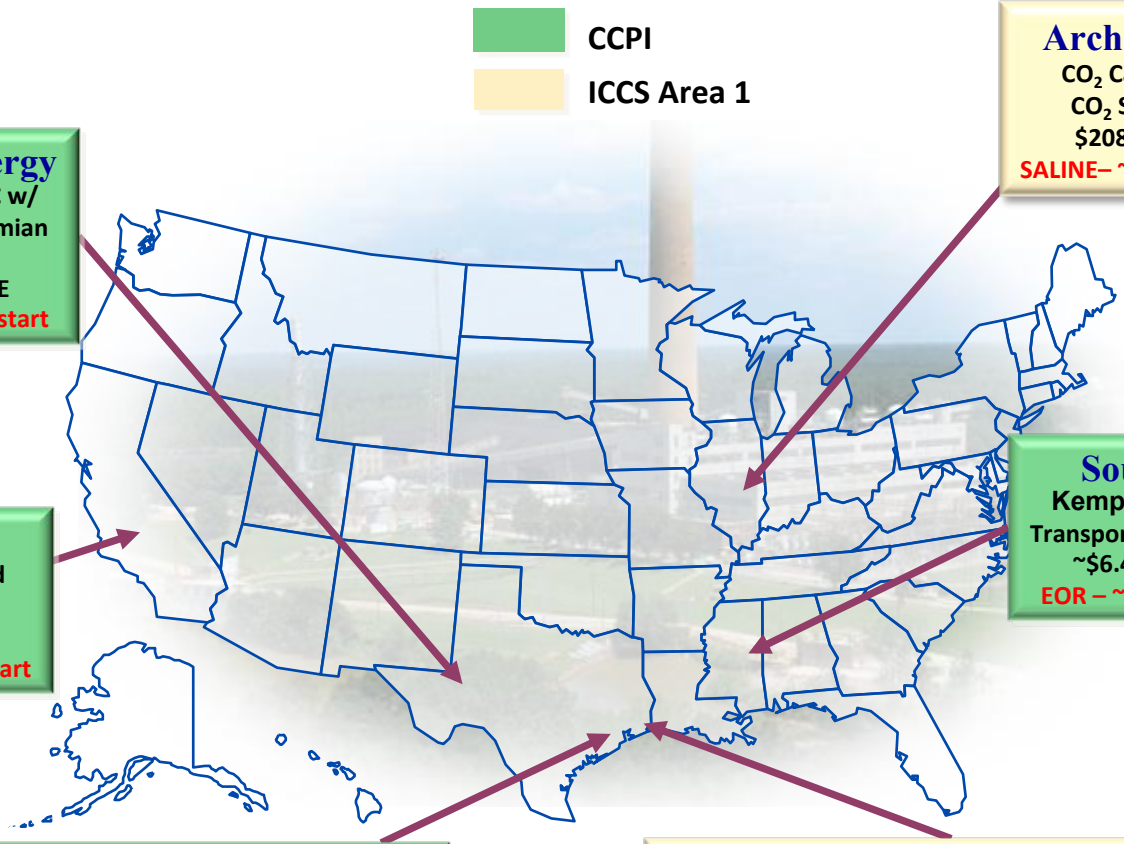
May 13, 2015

Major CCS Demonstration Projects

Project Locations & Cost Share



Archer Daniels Midland
CO_2 Capture from Ethanol Plant
CO_2 Stored in Saline Reservoir
$208M – Total; $141M – DOE
SALINE– ~0.9 MM TPY; Sept. 2015 start

Summit TX Clean Energy
Commercial Demo of Adv. IGCC w/ Full Carbon Capture; EOR in Permian Basin
~$3.5B – Total; $450M – DOE
EOR – ~1.84 MMTPY; late 2018 start

Southern Company
Kemper County IGCC Project
Transport Gasifier w/ Carbon Capture
~$6.4 B – Total; $270M – DOE
EOR – ~3.0 MM TPY; mid-2016 start

HECA
Commercial Demo of Advanced IGCC w/ Full Carbon Capture
~$5B – Total; $408M – DOE
EOR – ~2.6 MM TPY; mid-2020 start

Petra Nova
W.A. Parish Generating Station
Post Combustion CO_2 Capture
$1B – Total; $167M – DOE
EOR – ~1.4 MM TPY; early 2017 start

Air Products & Chemicals, Inc.
CO_2 Capture from Steam Methane Reformers
EOR in Eastern TX Oilfields
$431M – Total; $284M – DOE
EOR – ~0.93 MM TPY; started December 2012; 1.9 MMT stored as of April 2015

Portfolio of Capture and Storage Approaches

	Plant Type		Sequestration			Feedstock
	Power	Industrial	Saline	EOR	Rate*	
Pre-combustion						
HECA (IGCC-Polygen)	X	X		X	2.57	NM Sub-bituminous Coal/Petcoke Blend
Southern-Kemper Co. (IGCC)	X			X	3.0	MS Lignite
Summit Texas (IGCC-Polygen)	X	X		X	1.84	WY Sub-bituminous Coal
Air Products and Chemicals, Inc. (SMR)		X		X	0.925	Natural Gas
ADM (Ethanol Production)		X	X		0.900	Corn Fermentation
Post-combustion						
Petra Nova	X			X	1.4	WY Sub-bituminous Coal

Clean Coal Power Initiative (CCPI)

Industrial Carbon Capture & Storage (ICCS, Area 1)

*Rate in million metric tons per year

Southern Company Services, Inc.

Advanced IGCC with CO_2 Capture

- Kemper County, MS
- 582 MWe (net) with duct firing; 2 TRIG™ gasifiers, 2 Siemens combustion turbines, 1 Toshiba steam turbine
- Fuel: Mississippi lignite
- 67+% CO_2 capture (Selexol® process); 3,000,000 tons CO_2/year
- EOR: Denbury Onshore LLC, Treetop Midstream Services LLC
- Total DOE CCPI Project: $2.01 B; DOE Share: $270 MM (13%)
- Total estimated project cost: ~$ 6.4B

Key Dates

- Project Awarded: January 30, 2006
- Project moved to MS: December 5, 2008
- NEPA Record of Decision: August 19, 2010
- Initiate excavation work: September 27, 2010
- Operations: mid-2016

Status

- Plant construction >98% complete; Peak construction labor 6,121
- CO_2 off-take agreements signed
- Lignite mine in commercial operation: June 2013
- Subsystems commissioning in progress
- Combined cycle commercial operation on natural gas: August 2014
- Gasifier “First Fire”: March 2015

Development of the TRIG™ for Power & Chemical Production

Late 30's — Orthoflow™ A Design

1942 — Orthoflow™ C Design

1951 — Resid FCCs

Early 1960's — Orthoflow™ F Design

1976

1980's — Design Based on FCC Technology

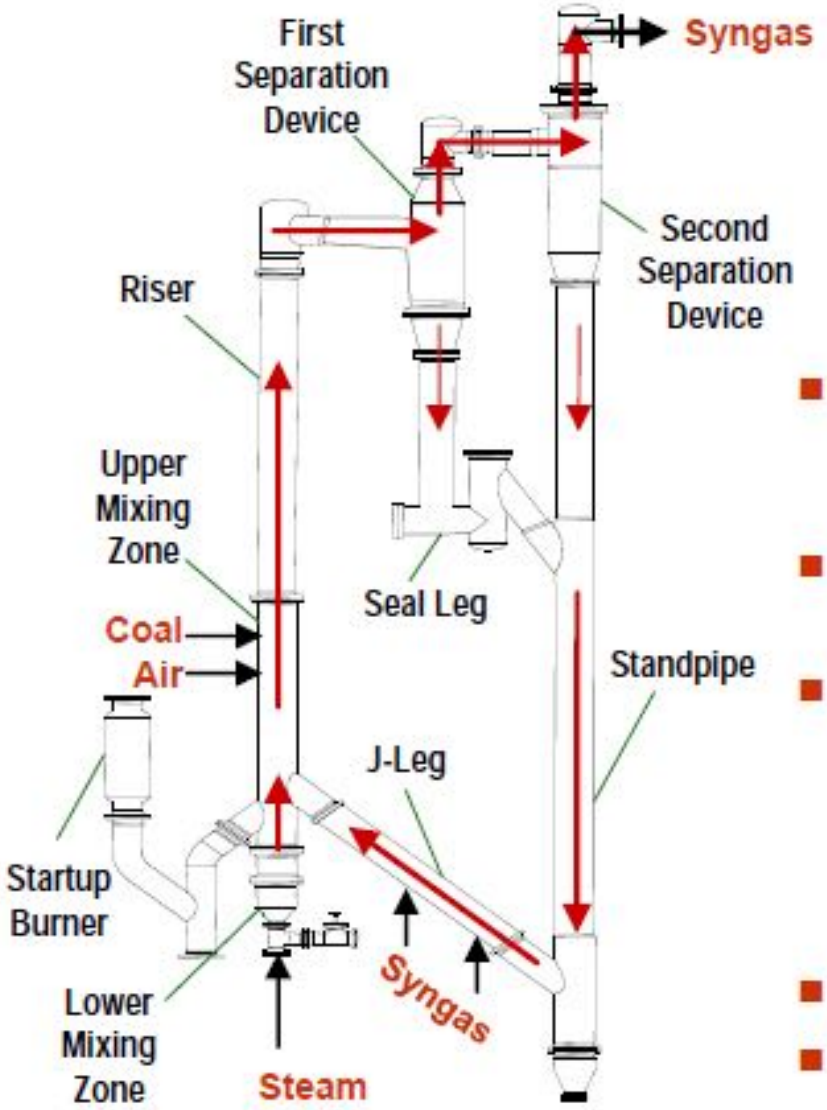
1990 — Pilot Plant Tech Center

1996 — Grand Forks, ND 2,600 Hours Test Run

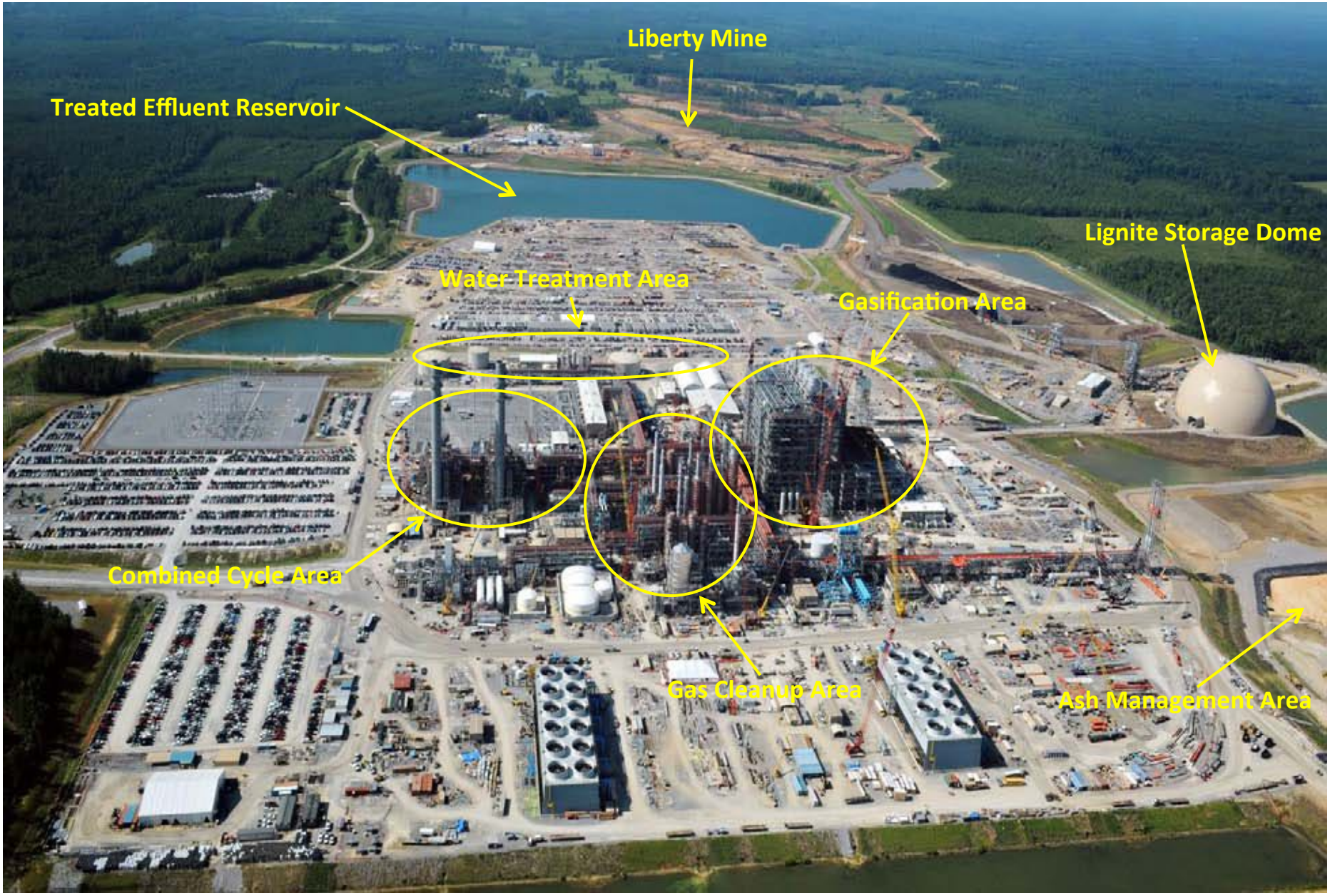
1996 — PSDF at Wilsonville, AL. >14,600 hrs in gasification >2,200 hrs on Mississippi Lignite thru Dec '09

China 2011 USA 2014 — TRIG™ In Kemper County, MS, USA & Dong Guan, China

TRIG™ Attributes/ Advantages



- **Simple, Well Established Design**
  - Based on technology in use for 70 years
- **Air-Blown Design for Power Generation**
- **Moderate Gas Temperatures**
  - Less expensive materials of construction
  - 10-20 year refractory life
  - No slag – ash leaves as a powder
- **Dry Feed ideal for High Moisture Fuels**
- **Lower Cost Carbon Capture Compared to PC**


Liberty Mine
Treated Effluent Reservoir
Lignite Storage Dome
Water Treatment Area
Gasification Area
Combined Cycle Area
Gas Cleanup Area
Ash Management Area

Inside the Boxcut

Commissioning Activities – Steam Blow

Gas Cleanup Area

Syngas Scrubber and Water Gas Shift Reactors

Sulfuric Acid Tanks

Crystallizers in Water Treatment Plant

Combined Cycle Plant

Petra Nova – NRG W.A. Parish CCPI-3

Advanced Post Combustion CO_2 Capture

- Thompsons, TX (near Houston)
- 240 MWe slipstream at NRG Energy's W.A. Parish power plant (originally 60 MWe)
- Fuel: PRB sub-bituminous coal
- 90% CO_2 capture (KM CDR Process®) 1,400,000 tonnes CO_2/year
- EOR: Hilcorp West Ranch oil field
- Total Project Cost: ~$1 billion
  DOE Share: $167 million

Key Dates

- Project Awarded: May 2010
- Air Permit: December 2012
- NEPA Record of Decision: May 2013
- Financial Close: July 2014
- Construction: March 2014 (LNTP);
  July 2014 (NTP)
- Operation: January 2017

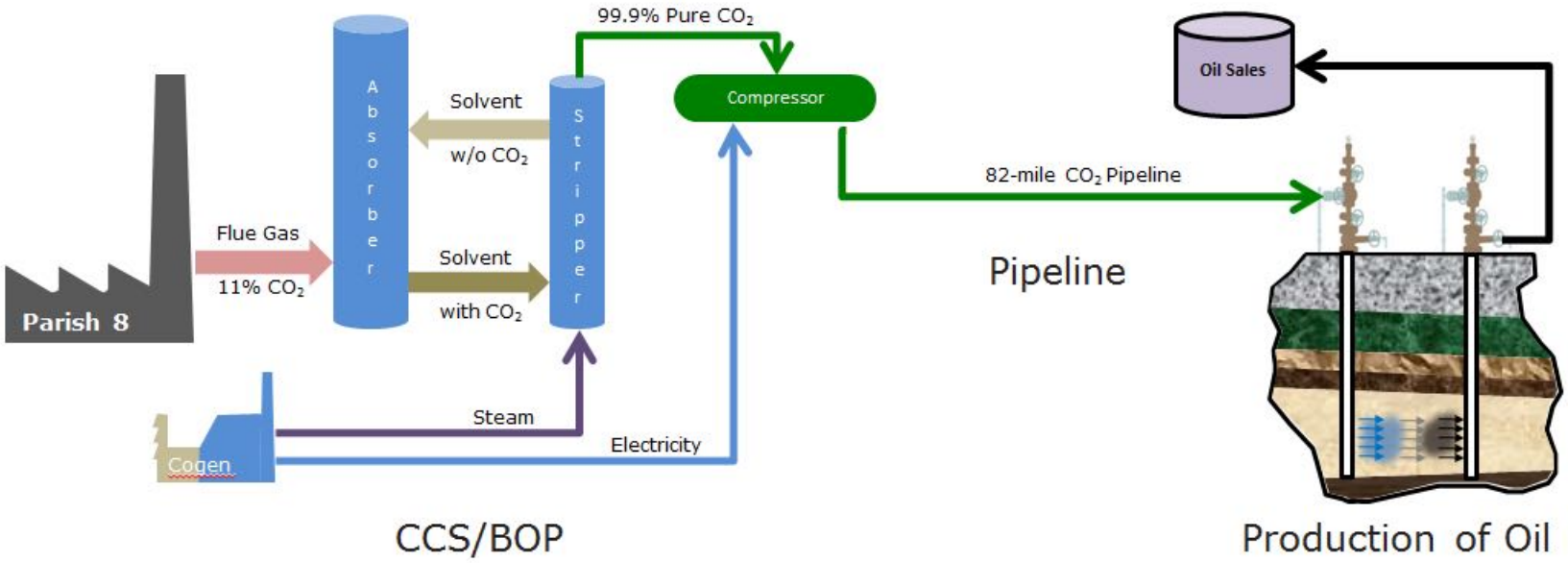
Status

- Foundations completed for quencher, absorber, regenerator, compressor & HRSG
- Construction in progress on quencher, absorber, HRSG, cooling tower & pipeline
- Regenerator being shop fabricated & compressor being manufactured
- Start absorber/quencher foundation Feb. 2015
- Overall EPC effort: 52% complete
- Construction: 13% complete

Petra Nova – NRG W.A. Parish CCPI-3

Overview

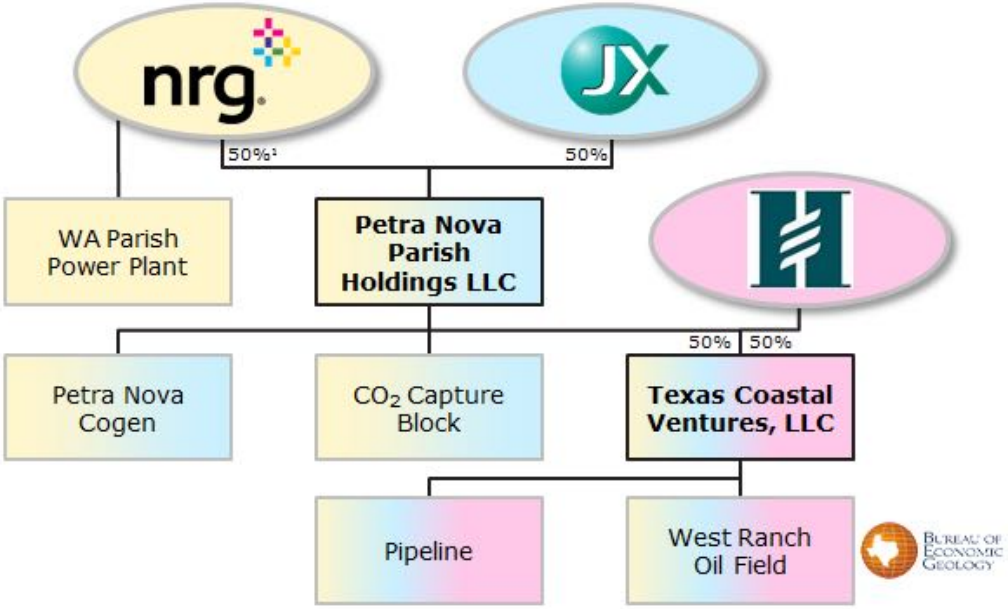
- The project will capture CO_2 and send it to nearby oil fields for carbon dioxide enhanced oil recovery (CO_2 – EOR), which is a long-proven method of producing stranded oil.
- DOE's goals are to demonstrate integration of carbon capture at an existing plant, protocols for CO_2 monitoring to ensure permanence of sequestration, identify areas for cost reduction
- Design will utilize a stand-alone technology natural gas cogen to simplify retrofit, provide flexibility in matching parasitic energy demands, without disrupt existing plant performance.



Petra Nova – NRG W.A. Parish CCPI-3

Partners and Transaction Structure

Project Ownership Structure



Sources	$MM
NRG Equity[2]	$300
JX Nippon Equity	300
Project Financing	250
DoE Grant	167
Total	**$1,017**

Uses	$MM
Parish Site Capital[3]	$637
Oilfield and Pipeline Capital	300
Initial O&M, G&A, Fees, Other	80
Total	**$1,017**

Partner Summary

Hilcorp Energy

- One of the largest privately-held oil and natural gas E&P companies in the US
- Strong track record of implementing new production techniques into mature reservoirs
- Specialized team that has extensive experience implementing CO_2 floods

JX Nippon Oil & Gas Exploration

- Currently conducting oil and natural gas business in 14 countries
- Parent company, JX Holdings, is a leading integrated energy, resources, and materials company

Japan Bank for Int'l Cooperation

- Policy-based financial institution
- Wholly-owned by the Japanese government
- Over 25,000 loan and equity commitments valued at over $479 billion

NEXI

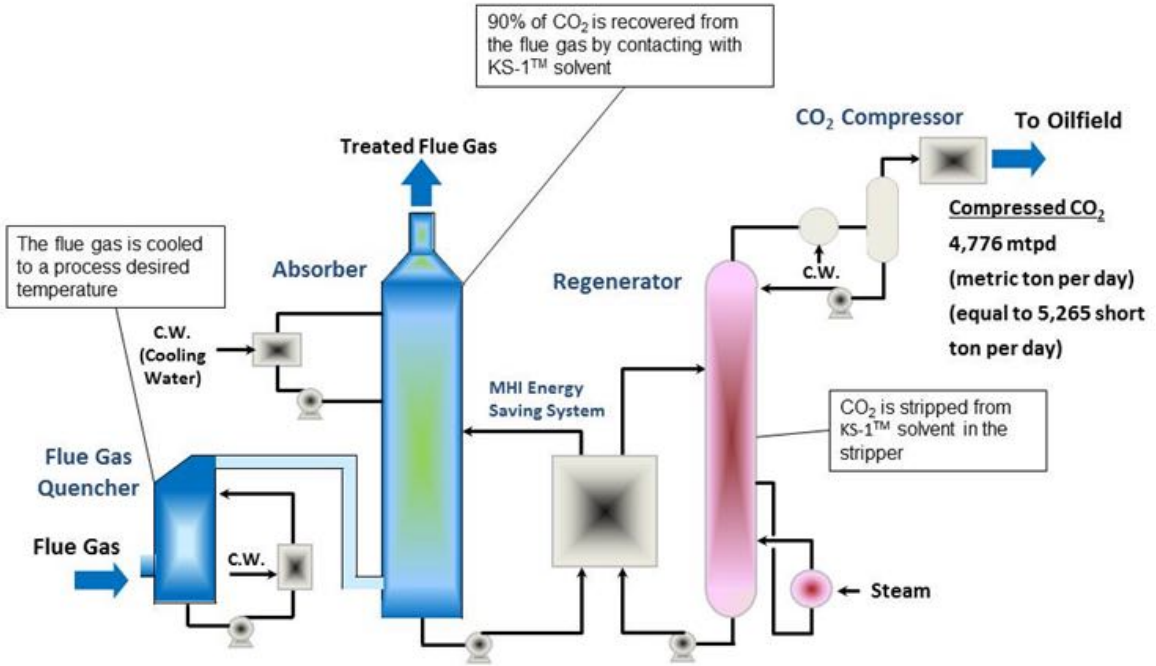
US DoE

- Awarded $167 MM grant
- Funded through Clean Coal Power Initiative

Petra Nova – NRG W.A. Parish CCPI-3

MHI KM-CDR Process®

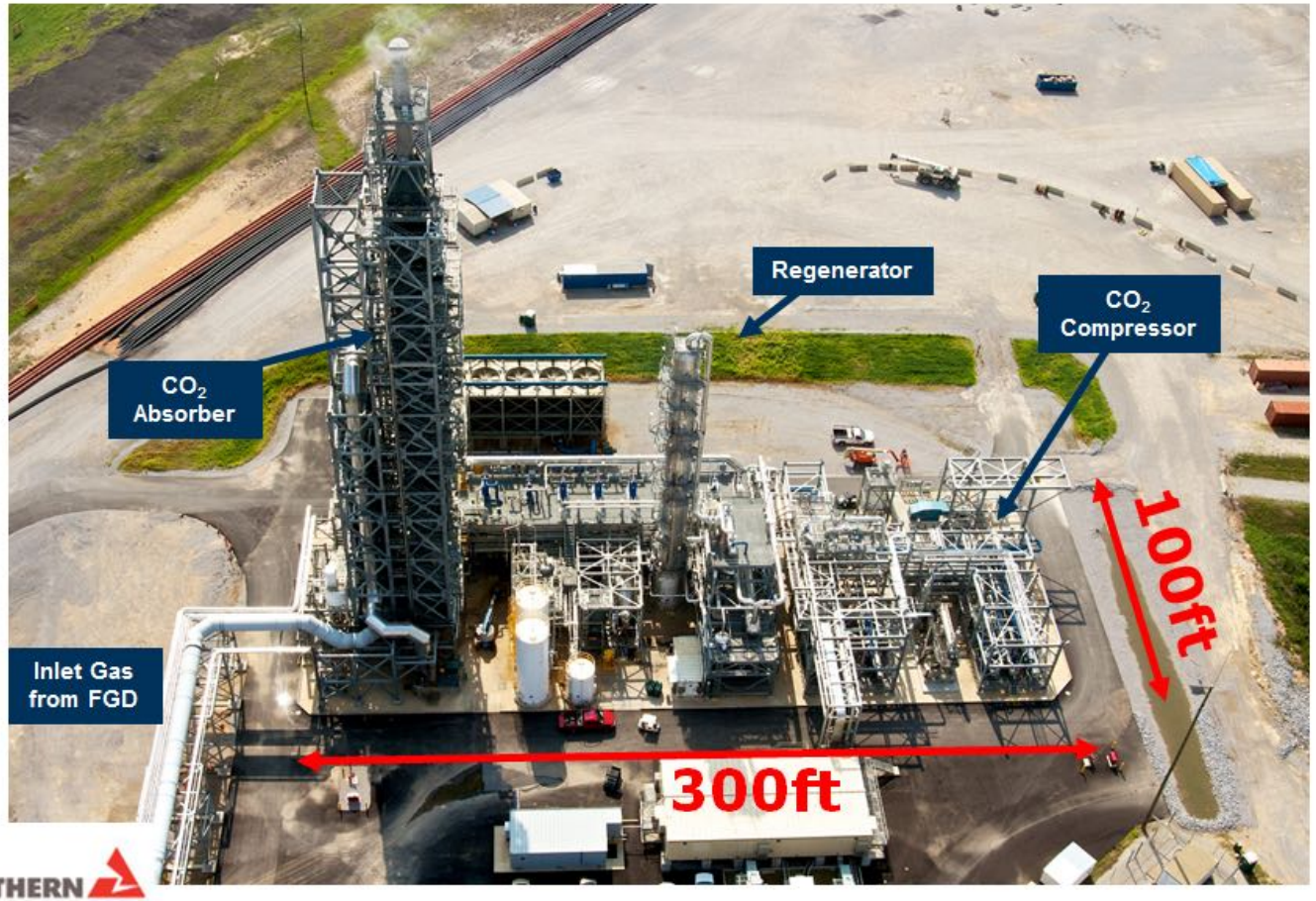
- Kansai Mitsubishi Carbon Dioxide Recovery Process (KM CDR Process™ comes from one of the world's most advanced industrial R&D programs (commenced in 1990 and ongoing).
- Commercially applied since 1999: 11 plants under operation.
- The 'Complete Solution' - hindered amine solvent "KS-1™ " with accompanying proprietary equipment.



https://www.mhi-global.com/products/detail/km-cdr_process.html

US 500 Metric TPD Coal Fired CCS Demo Project

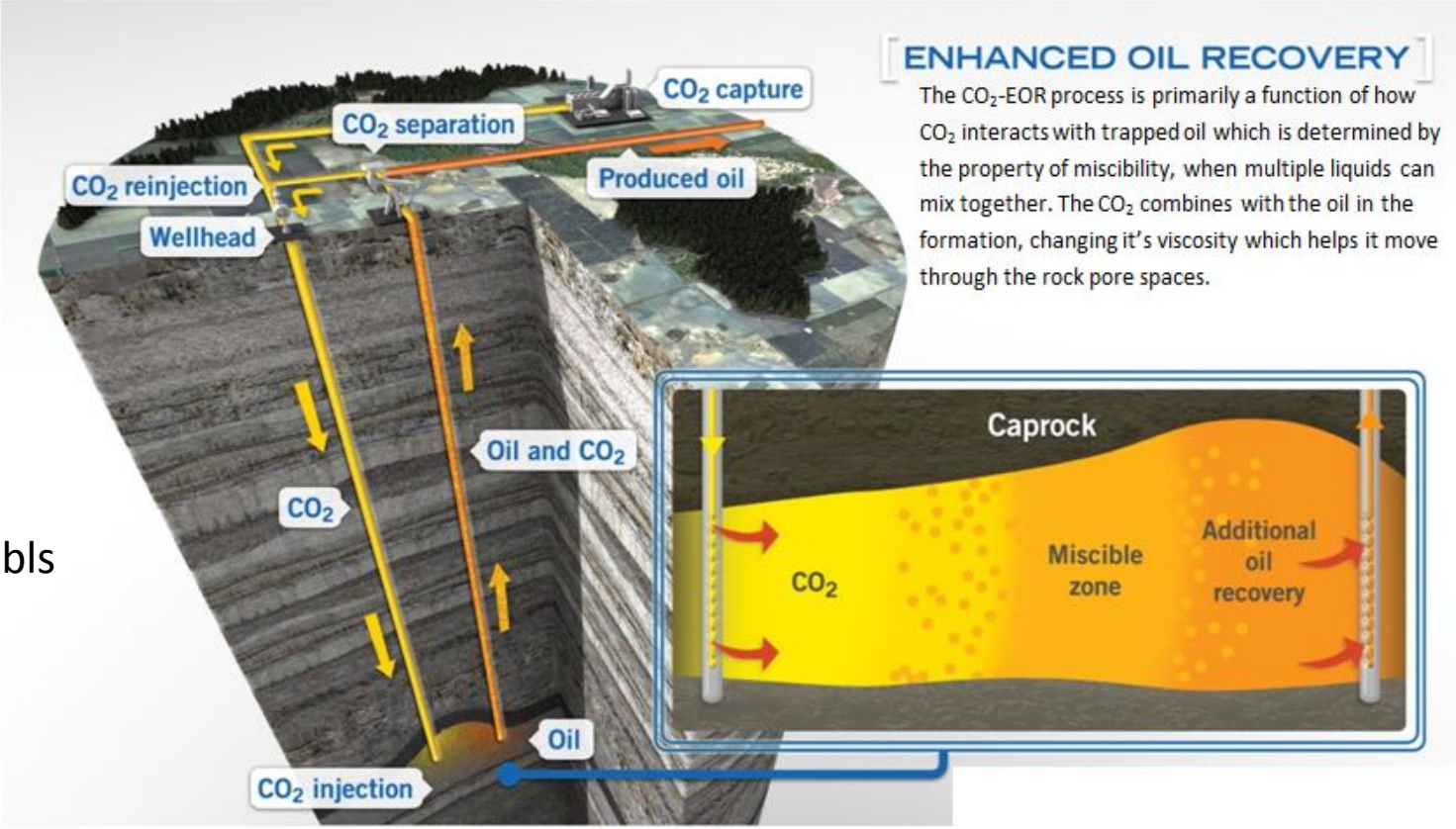
Successful demonstration of the SoCo 500 Metric TPD Integrated CCS Demo Project has lead to MHI being able to provide guarantees for coal flue gas CDR plants



https://www.mhi-global.com/products/detail/km-cdr_process.html

CO_2 - EOR Fundamentals

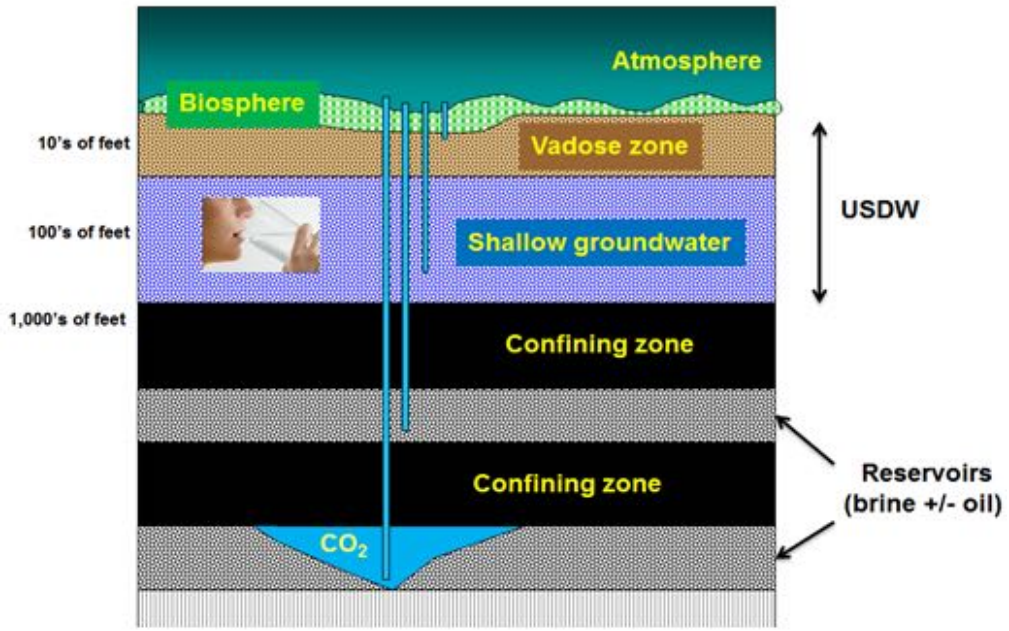
- Large scale CO_2-EOR has been proven successfully since the early 1970s to produce otherwise unrecoverable oil from mature fields (tertiary recovery).
- Its a closed-loop system where the CO_2 produced with the oil is separated and re-injected.
- 1 ton of CO_2 can produce up to 4 bbls of oil.
- 60MM bbls are estimated to be recoverable at West Ranch



http://www.globalccsinstitute.com/understanding-ccs/how-ccs-works-storage

CO_2 Monitoring Plan

- Monitoring responds to the goals of the DOE Cooperative Agreement.
- Industrial experience indicates that CO_2 retention during EOR is good, however additional monitoring is needed to demonstrate this value as part of a capture and storage project
- The monitoring approach is linked to the site-specific conditions, including geology and past and planned operations.
- Monitoring needed for optimization of operation and surveillance of oil recovery, and for Class II protection of Underground Sources of Drinking Water (USDWs) is enhanced to document isolation from atmosphere.
- Executed under a phased approach:
  - Phase 1 – Field Characterization and monitoring approach
  - Phase 2 – Baseline Monitoring & plan implementation.
  - Phase 3 – CO_2 monitoring (3 years)



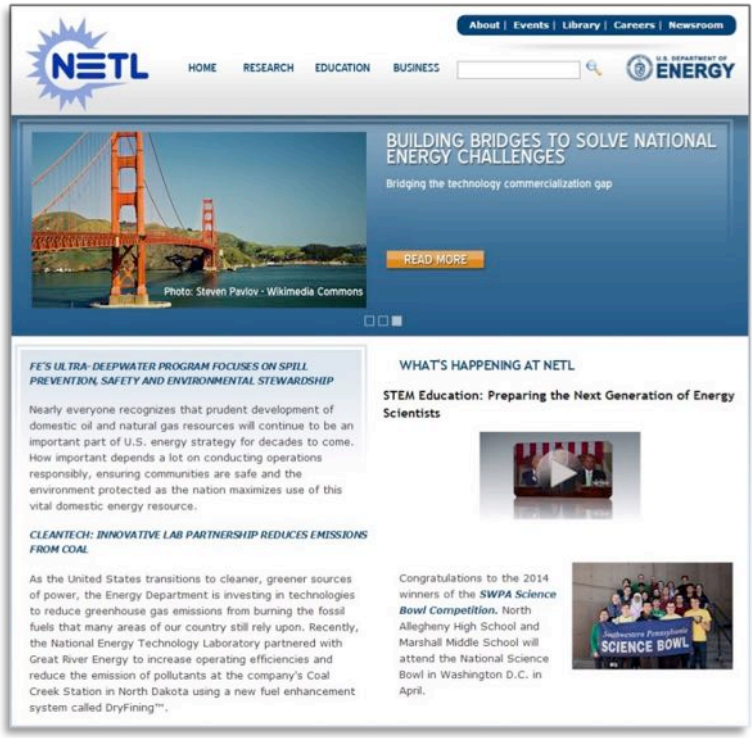
Petra Nova Construction

CCS Island

Petra Nova Construction

Heat Recovery Steam Generator (HRSG)

For Additional Information



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